THE annual volumes of Papers of the Michigan Academy of Science Arts and Letters are issued under the joint direction of the Council of the Academy and of the Executive Board of the Graduate School of the University of Michigan The editor for the Academy is Peter Okkelberg, for the University Eugene S McCartney

Previous publications of The Michigan Academy of Science now known as The Michigan Academy of Science, Arts and Letters, were issued under the title Annual Report of the Michigan Academy of Science Twenty two volumes were published of which those numbered 1 21 and 22 are out of print Copies of the other volumes are still available for distribution and will be sent on exchange as long as the editions last Applications for copies should be addressed to the Librarian of the University of Michigan

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MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

VOLUME XIX

CONTAINING PAPERS SUBMITTED AT THE ANNUAL MEETING IN 1933

PAPERS

OF THE

MICHIGAN ACADEMY OF SCIENCE ARTS AND LETTERS

EDITORS

EUGENE S. McCARTNEY

UNIVERSITY OF MICHIGAN

PETER OKKELBERG

UNIVERSITY OF MICHIGAN

VOLUME XIX

Pusilla res mundus est nisi in illo
quod quaerat omnis mundus habeat.'

— SENECA, *Naturales Quaestiones*

Ann Arbor

UNIVERSITY OF MICHIGAN PRESS

1934

Editor EUGENE S McCARTNEY
Set up and printed,
February 1934
Published March, 1933

PRINTED IN THE UNITED STATES OF AMERICA
BY THE PLIMPTON PRESS NORWOOD MASS

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THE BEGINNINGS AND GROWTH OF THE MICHIGAN ACADEMY OF SCIENCE, ARTS AND LETTERS

EUGENE S McCARTNEY
University of Michigan

> Pusilla res mundus est nisi in illo quod quaerat omnis mundus habeat
> Seneca, *Naturales Quaestiones*

THE Michigan Academy of Science, Arts and Letters is now a vigorous organization that is looking toward the future with every prospect of a long and useful career It outgrew its swaddling clothes so many years ago that but few persons can form a mental picture of it when enveloped in such a garb, and still fewer realize that it suffered the usual perils and vicissitudes of childhood Many of those who nurtured and reared the infant society have passed from this life The details of its birth and childhood have faded from the minds of the founders who survive,[1] so that the minutes of meetings are almost the only reliable source of information still available Unfortunately, they are silent in regard to many points that would interest us at this time

Now that the Academy has reached adulthood and is living a life of usefulness and achievement, interest is being shown in its early days, especially at the time of the annual meetings For this and other reasons it seems advisable to put into readily accessible form a longer account of its activities than has hitherto appeared in print

THE FOUNDING

Like most organizations, the Michigan Academy had its inception in the vision and the initiative of a few men The idea was con-

[1] A few months before his death one of the early presidents sent to me an answer which is typical of the replies I received in response to letters of inquiry addressed to the oldest members of the Academy "I do not believe that I can be of service in providing either spice or atmosphere for your history which I shall hope to see in good season '

ceived by Professor Jacob Reighard in the early 'nineties, while he was head of the Department of Animal Morphology of the University of Michigan His plan was to bring together the college and university teachers and other persons in the State who were interested in research The desirability of founding a State academy was obvious The only question in Professor Reighard's mind was whether there was sufficient interest at that time In order to reassure himself he broached the matter to various persons individually Among them were D C Worcester, then instructor in zoology at the University of Michigan, F C Newcombe, instructor in botany at the same institution, Frank McFarland, professor of biology at Olivet College, and W J Beal, professor of botany at Michigan Agricultural College These men and others gave Professor Reighard enough encouragement to warrant further steps

On March 22, 1892, Professor Reighard, together with V M Spalding, professor of botany, W H Howell, professor of physiology, and J B Steere, professor of zoology, all of the University of Michigan, addressed to a score of men well known in the State a proposal "to organize in Michigan a state society of naturalists to comprise zoologists, botanists, and physiologists" The chief purposes of this letter were to elicit expressions of opinion on the scope of the work that was to be done and on the character of the membership

In the spring of 1894 the time seemed ripe for further action, but, owing to Professor Spalding's absence in Europe, Professor Reighard's preparations to go abroad, and Professor Howell's having left the University, the task of organization fell upon others Under these circumstances Professor F C Newcombe, of the Botany Department, prepared, with the help of Professors J B Steere and W P Lombard, a circular letter, dated June 21, 1894, calling for a meeting of interested persons at Ann Arbor on June 27 for purposes of organization

This meeting, which was attended by over twenty-five persons, was called to order by F C Newcombe, who proposed W J Beal for chairman He was elected unanimously, and F C Newcombe was made the first secretary The need of such an organization and its opportunities for usefulness were recognized by all present "The general opinion expressed was that the society should hold stated meetings for the reading and discussion of scientific papers,

and should also seek to forward the scientific [study of the] resources of the state as well as [that of] the fauna, flora and so forth"

A motion was made and carried "that the officers of the association with the addition of two members be constituted an advisory board to report a constitution and by-laws, to arrange a program and to call the next meeting" The problem of a suitable name was referred to the advisory board

"As officers of the temporary organization, W J Beal was chosen president, J B Steere vice-president, F C Newcombe secretary and treasurer" Professor W B Barrows, of the Michigan Agricultural College, and Professor I C Russell, of the University of Michigan, were elected as the two other members of the advisory board

THE FIRST MEMBERS

The following comments from a founder and past president of the Academy reveal more clearly than anything else which I have found the spirit that actuated the first members of the Academy

"I recall with much pleasure the little family of kindred spirits who met to organize the Academy, my special interest being the service which this organization could render to the schools and colleges of the state, both in assisting the teachers in the collection and identification of our local material and in the encouragement which might be given these teachers in the study of such material This phase of the work of the Academy was stressed for the first few years and led to the issuance of a 'Booklet for Teachers of Zoology and Botany' Our meetings were always amiable — and Mr Alexander finally had his oak recognized (Britton & Brown ? [1]), even if not accepted at the time by the botanists of the Academy"

The membership list that was made at that time contains the names of thirty-four persons, sixteen of whom were connected with the University of Michigan Since it was chiefly upon their efforts and their faith in the future that the welfare and the growth of the Academy depended, their names are worthy of all honor by the present flourishing organization In this list the names of persons

[1] The validity, as a distinct species or variety of a certain chestnut oak named *Quercus Alexanderi* by Britton was a matter about which there was much dispute by local botanists In Gray's *Manual* it is not recognized as different from *Q Muhlenbergii*

who later became charter members are preceded by asterisks (*) The names are given as they appear in the minutes

Delia A Bailey Grand Rapids
*Hattie M Bailey, Grand Rapids
*Walter B Barrows, Michigan Agricultural College
*W J Beal Michigan Agricultural College
*Chas K Carpenter, U of M
*Chas A Davis Alma College
*E H Edwards, U of M
*Oliver A Farwell, Detroit
H S Jennings, U of M
*I N Johnson U of M
*Chas A Kofoid U of M
*Warren P Lombard U of M
S D Magers U of M
H C Markham U of M
J W Matthews, Grand Rapids
*J Montgomery Ann Arbor
*W H Munson Hillsdale College
*F C Newcombe U of M
*Mrs Lucy A Osband, Michigan State Normal College Ypsilanti
A J Pieters U of M
*I C Russell U of M
*J H Schaffner, U of M
*J B Shearer, Bay City
*W H Sherzer, Michigan State Normal College Ypsilanti
*Frances L Stearns Adrian College
*J B Steere U of M
*E A Strong, Michigan State Normal College Ypsilanti
*Bryant Walker Detroit
*H B Ward Nebraska University
*Margaret Weidemann U of M
*Chas F Wheeler, Michigan Agricultural College
*Mrs E G Willoughby, U of M
*Robt H Wolcott Grand Rapids
*D C Worcester, U of M

CHARTER MEMBERS

The Michigan Academy of Science was incorporated on February 6, 1895, under Act No 356 of the Public Acts of 1865, which is the act for the incorporation of societies for literary and scientific purposes

Twenty-eight of the thirty-four persons in the original membership list became charter members, as is indicated by the asterisks There were fifty-one other charter members, as follows

Henry C Adams, U of M
Henry B Baker, Lansing
Charles E Barr, Albion College
Herbert T Blodgett, Ludington
Francis D Clarke, Flint
Frank N Cole Ann Arbor
Leartus Connor Detroit
W M Courtis, Detroit
Arthur A Crozier Ann Arbor
Gager C Davis, Michigan Agricultural College
Joseph B Davis, U of M
Isaac N Demmon, U of M
Charles K Dodge, Port Huron
Newell A Eddy, Bay City
Charles W Garfield Grand Rapids
Heneage Gibbes, U of M
Morris Gibbs, Kalamazoo
A C Glidden, Paw Paw
Asaph Hall, Jr , U of M
George Hempl, U of M
Bela Hubbard, Detroit
Lucius L Hubbard, Houghton
Stillman G Jenks, Kalamazoo College
John B Johnston U of M
Francis W Kelsey, U of M
Clarence H Lander, U of M
Alfred C Lane Lansing
Warren H Lewis Ann Arbor
Frank R Lillie, U of M
C D McLouth, Muskegon
W P Manton, Detroit
Manly Miles, Lansing
Frederick G Novy, U of M

William H Pettee, U of M
Hoyt Post, Detroit
Jacob Reighard, U of M
Mrs Cynthia Sager, Ann Arbor
Louis T Schurrer, Lakeport
Loren A Sherman, Port Huron
Eugene C Skinner Detroit
Clinton D Smith, Michigan Agricultural College
Harlan I Smith, Saginaw
Volney M Spalding U of M
Jerome Trombley, Petersburg
M F Wadsworth Houghton
Oscar B Warren Palmer
L Whitney Watkins Manchester
F S Wheeler Sault Ste Marie
Charles A Whittemore, Grand Rapids
Mortimer Wilson Port Huron
Frank E Wood, Bay City

Many of the first members have won distinction beyond the borders of our state Some have gained international recognition Were it possible to introduce here a few biographical details and to list their most important achievements, it would be seen at a glance that there was great ability among the founders of the Academy We do not need to search for an explanation of the wisdom with which the youthful society was guided

OTHER DETAILS OF ORGANIZATION

At some time before September 15, 1894, there was held a meeting of the advisory board, at which "it was unanimously agreed to recommend that the name of the society be the 'Michigan Academy of Sciences,' [1] and that it have for its principal object the study of the agriculture, archaeology, botany, geography, geology, mineral resources, zoölogy, etc , etc , of the State of Michigan, and the diffusion of the knowledge thus gained among men It is not the opinion of the advisory board, however, that the work of the society should be restricted to the subjects named, but should be enlarged from time to time as occasion may require "

By the aid of the press of the State, which published the substance of a circular letter sent out on September 15, the membership was increased to eighty-six before December 1

The formal organization was completed at the first meeting, which was held, quite appropriately, in the Pioneer Room of the State capitol at Lansing on December 26–27, 1894 At that time the constitution and by-laws, which had been drawn up by the Advisory Board, were adopted The constitution declared that "The objects

[1] The plural number is used on the first program, but on later programs and in the bulletins reporting the first meetings the singular number is used Article I of the constitution, as printed in the *First Report of the Michigan Academy of Science*, uses the singular number

of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science "

THE FIRST PROGRAM

The program of papers for the first meeting has so much historic interest, both as a guide for future efforts and by way of contrast with present programs, that it is here given in full, as it was actually presented rather than as it appeared in printed form

Wednesday afternoon December 26

1 The Mammals of Michigan J B Steere
2 What Can We Do with the Birds of Michigan? D C Worcester
3 Additions to the Flora of Michigan C F Wheeler
4 The Cryptogamic Flora of Michigan I N Johnson
5 *Distoma petalosum*, a Parasite of the Crayfish C H Lander

Wednesday evening December 26

6 Our Society and a State Survey W J Beal
7 Bacteria and the Dairy C D Smith
8 Practical Benefits of Bacteriology F G Novy
9 Simian Characters of the Human Skeleton W H Sherzer
9a Some Notes on the Michigan Coat of Arms W J Beal

Thursday morning December 27

10 Vital Statistics C I Wilbur
11 Flora of Michigan Lakes Chas A Davis
12 Work of the Michigan Fish Commission H B Ward (Read by C A Kofoid)
13 Dinobryons of Lake Michigan C A Kofoid

Thursday afternoon December 27

14 Tendencies in Michigan Horticulture A A Crozier
15 Futile Experiments for the Improvement of Agriculture Manly Miles

The following papers were read by title

16 Data and Development of Michigan Archeology H I Smith
17 Michigan Lepidoptera R H Wolcott
18 Review of Our Present Knowledge of the Molluscan Fauna of Michigan B Walker
19 The Uredineae of Michigan Harriet I Merrow

According to an unofficial report of the meetings, "The thing started off very well, with thirty to fifty in attendance at the various sessions There were some very good papers read, as well as some poor ones "

In comparison with our present programs this one seems humble, but it contained a germ capable of infinite growth

OFFICERS

The constitution adopted at the first meeting provided for a president, a vice-president (now called "chairman") of each section that might be organized, a secretary, and a treasurer. These officers constituted an executive committee called the Council.

The first vice-presidents, who were chosen for the following year, were Professor J. Reighard for zoology, Professor F. C. Newcombe for botany, and Dr. H. B. Baker, of the State Board of Health, for sanitary science. The sections were split into divisions for special lines of work, with each division having a head of its own. We are told that in zoology there were sections for ornithology, mammalogy, and the study of invertebrates.

In 1898 past presidents were made members of the Council. At the present time all past presidents who have maintained their memberships and now reside in Michigan are members of the Council.

The office of librarian was created in 1903. The first incumbent was G. P. Burns. At that time only three *Reports* had been published, but the fourth was overdue.

The offices of secretary and treasurer were combined in 1904. On December 4, 1926, owing to "the steadily mounting labor connected with the office" of secretary treasurer, the Council moved to appoint a committee to select an acting treasurer until the next general meeting of the Academy, when a treasurer was elected.

When it was decided at the first meeting to divide the Academy into sections, the head of each section was called "vice-president," a designation that continued until 1924, at which time the name was changed to "chairman." In 1924 the office of vice-president as it is now known was created. In the same year the chairman of the local committee was made a member of the Council.

The first sixteen *Reports* were edited by the secretaries of the Academy. An editor was elected for the seventeenth and eighteenth *Reports*. Four *Reports*, 19–22, were edited by the chairman of a board of editors. At the present time a general editor for the Academy, together with a board of section editors, passes upon the papers submitted for publication. The work of preparing the papers for the printer and of seeing them through the press is done by the editor of scholarly publications of the Graduate School of the Uni-

versity of Michigan The current numbers of the *Reports*, which contain the proceedings, are handled entirely by the Academy editor

TIMES AND PLACES OF ANNUAL MEETINGS

The first of the two annual, or "winter," meetings, as they were called, was held at the end of December, 1894, in the Pioneer Room of the State capitol at Lansing At the second meeting, a year later, it was decided that spring would be a more suitable time for the annual gatherings, but inasmuch as that season was then only three months away no program was prepared for 1896 Since that time the meetings have been held in the spring, although the one for 1914 was planned for the fall The time was found unsuitable, however, and no meeting was held in that year

The third and fourth meetings were held at Ann Arbor, the fifth took place at Ypsilanti State Normal College, the sixth, at Michigan Agricultural College All the other programs have been at Ann Arbor A number of them were arranged for the same time as those of the Michigan Schoolmasters' Club

SUMMER MEETINGS

The constitution adopted at the first meeting at Lansing called for an annual summer meeting The first of these meetings was planned for Orion, Oakland County, May 30, 1895 According to the announcement, there was to be some general consultation, after which small parties were to be formed "to search for natural objects of most interest to them, whether it be algae, fungi, mosses, the higher plants, whether birds, reptiles, fishes, shell-fish, insects, crustacea, or geology, archaeology, or the microbes affecting the sanitary condition of the neighborhood"

"On account of inaccessibility but few members were able to attend, but those who did attend report a very profitable day About twenty people, members and friends of the Academy, were present, representing the sections, and the country was as thoroughly explored as possible No formal account of the results of the explorations was made, and as the secretary was not present, no further record than this note is preserved"

The second annual field meeting was held at Michigan Agricultural College on June 13, 1896 No formal papers were presented, but opportunity was given to inspect the scientific equipment

and resources of the institution The main value of the meeting seems to have been its social features The attendance was small

The third annual meeting took place in Detroit on August 10, 1897 Nothing was done in the name of the Academy except the transaction of a little business Field features were abandoned for this year in order that members might attend the sessions of the American Association for the Advancement of Science, which met in Detroit from August 9 to 14

At this point the minutes of the Academy suddenly become silent about summer meetings The reason for their abandonment was doubtless the small number in attendance In those days transportation had not been rendered easy by the automobile, and the number of scientists in the state was far less than at present

SECTIONS

At the first meeting of the Academy papers in botany, zoölogy, and sanitary science were presented before the entire society, but at this time the Academy appointed vice-presidents for the three sections named, although even in the second year's meeting papers were not presented by sections The program for the third year, however, is divided into such groups

The additions and discontinuance of sections, as well as changes in names, are as follows

Section of Agriculture authorized June 13 1896, but no separate program in this subject was announced before 1900 The last meeting of this section was held in 1922 [1]

Subsection of Conchology within Section of Zoölogy authorized June 13 1896

Section of Geology and Geography seems to have been authorized March 27 1902, although the minutes merely state that the Council voted to give encouragement to the Section if eight or more men desired to organize one A meeting for organization and a program had already been announced on the general program

Section of Science Teaching authorized March 28 1902, discontinued April 1, 1910

Name of Section of Sanitary Science changed to Section of Sanitary and Medical Science April 1, 1909

Section of Economics authorized March 31, 1910

[1] The members who attended the meetings of the Section of Agriculture were so few and from so small an area that they had been making the pilgrimage to Ann Arbor principally to see and hear friends with whom they had been in intimate association in their home town of Lansing!

Section of Psychology authorized March 29, 1918

Section of Anthropology to be recognized by Council upon presentation of a petition with the proper number of signatures Action of April 2 1920

Section of Language and Literature authorized March 28, 1923

Name of Section of Geology and Geography changed to Section of Geology and Mineralogy March 30 1923

Section of History and Political Science authorized April 2 1924

Section of Mathematics authorized April 4, 1924

Section of Geography authorized April 2 1926

Name of Section of Economics changed to Section of Economics and Sociology April 2, 1926

Section of Forestry authorized March 30 1928

Section of Fine Arts authorized March 30 1928, discontinued 1933

Section of Philosophy authorized March 18, 1933

GEOLOGICAL EXCURSIONS

Since the spring of 1931 annual field excursions to areas of special geological interest in Michigan have been sponsored by the Section of Geology and Mineralogy They have been unusually well attended by professional geologists, graduate students, and other persons and have stimulated the study of problems in Michigan geology

The first excursion, that of May 22–24, 1931, was concerned with an examination of the rocks of Mississippian age exposed along the shore of Huron County and at places on and near the western shore of Saginaw Bay

The next excursion, May 28 30, 1932, made its special study the Pleistocene geology of south-central and southwestern Michigan The leader, Dr Frank Leverett, pointed out the chief features of the glacial and postglacial history of this part of the State

The party examined the site [1] from which Professor E C Case had recently exhumed a large part of the skeleton of a fossil elephant [2] Problems connected with the burial of the animal were discussed by Professor I D Scott and Dr Leverett

On the morning of the same day the party had learned of the unearthing of the jaw and a few other bones of a mastodon on the farm of Mr G Wattles, near Colon, St Joseph County It took advantage of this unexpected opportunity and proceeded to Colon,

[1] On the farm of George Wagner, near the town of Union in the southeastern corner of Cass County

[2] Now in the Museum of Paleontology of the University of Michigan

where the remains were on exhibition They proved to be of considerable importance, because they had belonged to a very young animal [1]

The large sand dunes along the Lake Michigan shore between Saugatuck and Holland were included in the itinerary of 1932 Their mode of formation and destruction was explained by Professor Scott

The excursion of May 27–28, 1933, had as its objective an examination of the stratigraphy of the Pennsylvanian strata of Grand Ledge, Ionia, Williamston, and other places near Lansing Several cyclical formations and interformational unconformities in the Pennsylvanian were studied under the guidance of Professor W A Kelly, of the Department of Geology of Michigan State College The complicated history of the deposition and erosion of the Pennsylvanian strata of the Grand Ledge area, which had been worked out by Professor Kelly, was very interesting to the party

On the second day some of the members of the party accompanied Dr Leverett on a special trip to examine certain changes in the glacial drainage of the Grand River This part of the program was intended to supplement the knowledge of the drainage changes observed during the excursion of 1932

During each excursion an evening is devoted to a résumé and a discussion of the things seen Everyone feels free to ask questions

These trips are both delightful and instructive Members and friends of the Academy who are not geologists are invited to take part in them and are cordially welcomed The only prerequisite is an interest in geology - real or assumed for the occasion

CHANGE TO PRESENT NAME

In 1921 plans were being formulated to have the University of Michigan take over the publication of the Academy volumes and to widen the scope of activities by the formation of sections in Arts and Letters At a meeting of the Council on April 23, 1921, a motion was passed to change the name of the Academy to read as follows

[1] A few days later members of the Museum of Paleontology of the University of Michigan visited the farm and found several ribs and bones of limbs of the same animal Thanks to the generosity of the owner of the farm, all the bones are now preserved in the Museum of Paleontology

The Michigan Academy of Science, Arts and Letters This matter was not formally acted upon by a general meeting of the Academy until March 30, 1923, although the new name had appeared on the program of the twenty-seventh annual meeting held on March 29–31, 1922

The chief advocate of an increase in the number of sections was a good friend of the Academy, the late Alfred H Lloyd, dean of the Graduate School, who felt that the use of the comparatively meager funds available at that time for publication should not be restricted to particular groups The number of new sections that have been formed in the last decade is proof of the wisdom of Dean Lloyd's position

PUBLICATIONS

The success of a scientific society whose chief concern is the acquisition and diffusion of knowledge depends on having a suitable means of recording and disseminating the results of research This necessity was clearly realized at the first meeting of the Academy, at which "the whole matter of publication was referred to the Council, with power to act "

"The first publication of the Academy was a [four-page] leaflet giving a very brief account of the meeting at Lansing " In May, 1904, there began to appear a quarterly publication called *The M A S Bulletin,* the name of which was later changed to *Bulletin of the Michigan Academy of Science* According to the issue of May, 1904, "The purpose of this *Bulletin* is to bring the members of The Michigan Academy of Science into closer relation with one another and with the organization, to provide for means of communication between the officers and members, and to present to others the advantages of membership in The Academy, whose object is to encourage research, disseminate scientific knowledge, and promote harmony and unity in scientific study " The *Bulletin* seems to have ended with the issue of March, 1909, which contains nothing but the annual program It had gradually ceased to perform the duties for which it was instituted

The struggle for an adequate vehicle of publication, which began when the first meeting referred the matter to the Council, was destined to be a long one At a session of the Council on January 16, 1895, it was decided to ask the State to print the proceedings and

papers of the Academy The first efforts and others failed, but the Academy continued its petitions for legislative aid until 1899, when the legislature authorized publication

In 1900 there appeared the *First Report of the Michigan Academy of Science*, consisting of 180 pages and a few illustrations It was a great step forward, but difficulties still continued The State had placed a limit of 250 pages upon the size of the volumes, and the Academy was not satisfied with the form and appearance of the initial *Reports* It was not until 1915 that the committee on publication could announce that the limitation on the number of pages had been removed by the board of State auditors Some minor improvements were made in the last few numbers of the twenty-two volumes of *Reports* published by the State

It is worthy of note that the *Eleventh Report* honors Charles Darwin and is called the "Darwin Centenary Publication"

In 1914 no meeting of the Academy was held, but material for a *Report* was secured by canvassing the membership for papers

After the withdrawal of State aid in publication[1] an agreement was reached in 1921 with the University of Michigan whereby the annual volumes were to be issued under the joint direction of the Academy Council and the Executive Board of the Graduate School of the University By action of the Academy Council on December 16, 1922, the title of the volumes was changed to *Papers of the Michigan Academy of Science, Arts and Letters*

At the present time (September, 1933) eighteen volumes, totaling more than 9,000 pages, have been published Two were issued for the year 1926, and two have appeared for each meeting since that of 1928 All these volumes are profusely illustrated Volumes XVII and XVIII contain papers from eleven sections, in the *First Report* only four sections are represented Owing to retrenchment caused by the depression only one volume will appear for the year 1933 In supporting the present large and well-made volumes the University has been extremely generous The officers and members of the Academy have ever been fully aware of its debt to the University for its present prosperity

Reports containing the proceedings of the Academy are still be-

[1] The *Reports* were cast adrift informally through failure to provide funds by an appropriation bill I am informed, however that the needs of the Academy had been recognized in the printed list of appropriations

ing published every two or three years They are devoted chiefly to programs and the minutes of meetings

THE EXCHANGE LIST

One of the most gratifying and valuable results of the increased facilities for publication has been the growing exchange list On March 1, 1933, the number of societies and institutions on the list had reached 505, of which 337 are foreign The annual volumes which at the turn of the century aspired to attain state-wide importance have now become cosmopolitan The books and periodicals which are received in exchange for them constitute important additions to the University of Michigan Library, where they are available for use by all members of the Academy

RELATIONS WITH LEARNED SOCIETIES

Since 1920 the Academy has been affiliated with the American Association for the Advancement of Science It represents the Association in the State of Michigan and receives a small financial allowance from it annually Like other affiliated academies, the Michigan Academy aids in carrying on the work of the Association and is represented on its Council

On several occasions learned societies have met in Ann Arbor at the time of Academy meetings and have combined with various sections in making up programs

Contacts with research workers have often been made by appointing delegates to meetings of other organizations and even to international congresses

CITATIONS

In order to promote the spirit of research the Academy Council approved on March 31, 1931, a plan whereby citations should be conferred upon members who do meritorious original work with limited facilities and under peculiarly difficult conditions The principal purpose of this innovation is to recognize and reward research workers who live at a distance from centers of investigation

This honor was bestowed for the first time on March 17, 1933, when it was granted to Professor A M Chickering, of Albion College, in recognition of his work on the cytology of spermatogenesis in the Hemiptera and his systematic studies of the Arachnida

INFLUENCE UPON STATE LEGISLATION AND ADMINISTRATION

The influence of the Academy in proposing and encouraging legislation looking toward the conservation of the natural resources and the general welfare of the State of Michigan has been marked It is a lasting tribute to the pioneers who founded the society that they were the first body to recognize some of the State's most complex problems and to take some action

The Academy was organized just after the lumber industry in Michigan had passed its peak and when the adverse results of destructive lumbering, with its corollaries of idle land and taxation problems and great changes affecting the fauna and the flora of the State, were beginning to be noticed and felt

At the first meeting there were resolutions relating to a topographic map of the State, better registration of births and deaths in Michigan, passage of a bill in regard to forest reservations, indorsement of the work of the Michigan Fish Commission, increased appropriation for the continuance of the biological examination of the waters of the State by the Michigan Fish Commission, and the inauguration of a natural-history survey of the State This was an ambitious program Not a great deal was accomplished immediately as a result of it, but it was important as blazing the trail for future sessions

In the following year the Section of Zoology was directed "to take such means by securing proper legislation or otherwise, as will more effectually preserve the useful and harmless birds of the State" The third meeting cordially indorsed a forestry bill and expressed the opinion that "it would be a mistake should not the present Legislature pass a bill providing for fire protection, at least for the newer portions of our state" It also "*Resolved* that the Postmaster General of the United States be requested by this Academy to instruct the delegate of the U S Govt to the International Postal Congress about to meet in Washington to vote in favor of the proposed amendment to Article XIX of the Regulations of the Universal Postal Union which shall permit specimens of natural history to be sent through the mails at the same rate as samples of merchandise, and that packages be allowed according to the English Parcel Post"

At the fourth session of the Academy "It was moved that a committee be appointed to prepare for the signature of the mem-

bers of the Academy a petition that the United States Department of Agriculture will take steps to send a special commission to investigate the forestry problem of Michigan "

The fifth session requested the rehearing of a bill for the repeal of the English sparrow bounty law, as well as the actual repeal of the law

Since the first five meetings the Academy has never ceased to follow the precedent so well established by its early members Copies of resolutions take up an increasingly large part of the minutes as the years go by The Academy has urged or furthered legislation for topographical, archaeological, biological, geological, and land-economic surveys It has worked for the protection and conservation of plant and animal life, the establishment of parks to preserve things of scientific, historical, and recreational value, as well as the setting aside of areas of natural scenic beauty, and the restoration to productivity of idle and waste lands caused by deforestation Perhaps no subject has received more consideration than forestry and its attendant problems

In March, 1917, the Academy, recognizing that the nation was "without adequate land and naval forces for its defense," passed resolutions urging "upon the Congress of the United States the adoption at the earliest possible moment of the Chamberlain or other like bill for universal military training " Copies of the resolutions were sent to the president of the United States, to Senator Chamberlain, and to the senators and representatives from Michigan

In no legislation has the influence of the Academy been more marked than in that leading to the establishment of the Land Economic Survey In 1919 the Academy took cognizance of the pressing problems created by the increasing area of nonproductive lands in Michigan Since it had within its membership men trained in many sciences, it was probably the body best fitted to make appropriate recommendations At the twenty-fifth meeting, in 1920, a symposium on the idle lands of Michigan was held Among the resolutions passed at that time there was one of great significance

"That an inventory be made of the land resources of Michigan, by counties This inventory should constitute a series of county reports, accompanied by maps, along the following lines (*a*) nature of physical conditions, (*b*) present economic conditions, together with the record of past and present experiences in the use of the area, (*c*) a classification of the land according to its highest indicated use "

After concerted efforts by individuals, organizations, the Univer-

sity of Michigan, and Michigan Agricultural College, the Legislature authorized a "Soil and Economic Survey," and Michigan became "the laboratory for the working out of land classification technique and its wholesale application in the field"

Such an inventory was without precedent, so that the work of the first year was necessarily experimental, but it justified itself and the State has continued to maintain the survey Land inventories have since been undertaken by other states, and even the Federal Government has been influenced by the example set in Michigan

The Academy has always had among its members men well informed on and deeply concerned about the natural resources of the State Their special scientific knowledge and their counsel have always been available in legislative matters It has been a great advantage to the State to have within it a body of men with no pecuniary interest in the recommendations and resolutions it has made

Direct and indirect cooperation between the State and members of the Academy is constantly increasing Many of the men who are working on State projects are also members of the Academy and frequently publish in its volumes the results of their investigations

The legislative recommendations made by the Academy have been numerous and far-sighted Is there any connection between its activities and the fact that "Michigan has grasped the significance of conservation in a more comprehensive manner than any other state"?

THE ACADEMY TODAY

The society whose beginnings required so much courage and planning is now enjoying the vigor of maturity Its members number over one thousand On the first program there were nineteen papers, several recent ones have listed over two hundred and fifty

The problem of a suitable medium of publication, which confronted the society for many years, has finally been solved The number of contributors to the volumes has been growing and fields of investigation have been widening

The *Reports* and *Papers* properly contain much material that is of primary concern to Michigan alone, but the volumes are now cosmopolitan Their pages embody results of exploration and research in many lands

The present members are numerous and active, but we do not flatter ourselves, rather do we honor the founders who made possible the privileges and the opportunities which we enjoy

OFFICERS OF THE MICHIGAN ACADEMY 1894–1934

ANNUAL MEETINGS		PRESIDENTS	VICE PRESIDENTS	SECRETARIES	TREASURERS
1	1894	†W J Beal (1833–1924)	J B Steere	F C Newcombe	F C Newcombe
2	1895	B Walker		C A Davis	E A Strong
3	1897*	†W H Sherzer (1860–1932)		W B Barrows	C E Barr
4	1898	†V M Spalding (1849–1918)			W H Munson
5	1899	†H B Baker (1837–1920)			
6	1900	J Reighard			
7	1901	C F Barr			"
8	1902	†V C Vaughan (1851–1929)		J B Pollock	
9	1903	†I C Russell (1852–1906)			R Pearl
10	1904	†F C Newcombe (1858–1927)			H L Clark
				SECRETARY-TREASURERS	
11	1905	A C Lane		C E Marshall	
12	1906	†W B Barrows (1855–1923)		"	
13	1907	J B Pollock		E F Bogue	
14	1908	M S W Jefferson			
15	1909	C E Marshall		W G Sackett	
16	1910	F Leverett		W S Sayer	
17	1911	F G Novy		G D Shafer**	
18	1912	W E Praeger		R de Zeeuw	
19	1913	L C Case			
20	1915*	A G Ruthven		"	
21	1916	E A Bessey			
22	1917	W H Hobbs			
23	1918	†L H Harvey (1879–1922)		I D Scott	
24	1919	F T Carlton		"	
25	1920	E H Kraus		"	
26	1921	W Giltner			
27	1922	A F Shull			
28	1923	R A Smith		C D La Rue	
29	1924	C Bonner		L R Dice	
30	1925	H H Bartlett	E S Brown	" "	
31	1926	†C H Cooley (1864–1929)	F Taylor	" "	

* No meetings were held in 1896 and 1914 (see page 8)

** Also acting treasurer for the unfilled term of W S Sayer, who died on April 30, 1909

OFFICERS OF THE MICHIGAN ACADEMY 1894–1934 (*cont.*)

ANNUAL MEETINGS		PRESIDENTS	VICE-PRESIDENTS	SECRETARIES	TREASURERS
32	1927	L. A. Chase	H. R. Hunt	I. R. Dice	R. B. Hall
33	1928	W. B. Pillsbury	J. H. Hanford	" "	" "
34	1929	W. H. Worrell	L. A. Kenoyer	D. V. Baxter	E. C. Prophet
35	1930	O. Kamm	A. E. R. Boak		
36	1931	E. S. McCartney	A. M. Chickering	I. J. Young	
37	1932	W. B. Hinsdale	H. T. Darlington		"
38	1933	C. R. LaRue	R. B. Newcombe		"
39	1934	H. A. Sanders	W. A. Kelly		" "

EDITORS

Editorial duties were performed by secretaries until 1915, when the first editor was elected. There have been four editors, as follows:

R. A. Smith, 1915–17
G. H. Coons, 1917–21
P. S. Welch, 1921–25
Peter Okkelberg, 1925–

LIBRARIANS

The office of librarian was created in 1903. There have been five librarians, as follows:

G. P. Burns, 1903–10
A. G. Ruthven, 1910–13
Crystal Thompson, 1913–19
Peter Okkelberg, 1919–22
W. W. Bishop, 1922 –

INDIAN WATERWAYS OF THE SAGINAW DISTRICT, MICHIGAN

FRED DUSTIN

LESS than a hundred years ago, or, to be exact, on September 13, 1837, a party of three men, Dr Douglass Houghton,[1] state geologist, and his assistants, Bela Hubbard and C C Douglass, left Detroit by wagon with Byron, Shiawassee County, as their immediate destination This place, for which great things had been hoped and predicted, consisted of two houses and a mill at the junction of the north and south branches of the Shiawassee River Here they procured a canoe and started on an exploration which took them to Saginaw, and from there up the Tittabawassee River to the site of the present village of Sanford and to Salt River, which enters the larger stream not far above Returning from this point to Saginaw, they procured a larger craft, a dugout thirty feet long, but so narrow that a paddle could be used on either side by a person seated in the center In this craft they made the river, bay, and lake trip to Fort Gratiot, about one hundred and fifty miles distant, where they took a steamboat for Detroit

Hubbard's story of this trip, with its fine descriptions, is a partial picture of the old Indian waterways when Saginaw, the Kahbayshaywayning, "Gathering Place" of the red men, was, as it is now, a center of travel

The drainage area of the Saginaw River comprises about 6,260 square miles It is the largest in the state, the Grand is second, with 5,570 square miles[2] It is formed by the junction of the Tittabawassee and Shiawassee rivers, which unite at the extreme southern boundary of the City of Saginaw, from which point to Saginaw Bay it is really a sluggish estuary of that body With a northeast or north wind of some duration the current may be reversed or brought

[1] Hubbard, Bela *Memorials of a Half-Century* (New York, 1887), pp 65 90

[2] *Water-Supply Paper 264, U S Geological Survey* (Washington 1910) p 60

to a standstill The early notices always referred to it as "Sagana Bay," or some other variation of the present "Saginaw"

The Tittabawassee, the source of which is in the springs of Ogemaw County, has as its principal branches the Tobacco, Salt, Chippewa, and Pine rivers, all entering on its western side

The Shiawassee rises in Livingston and Genesee counties, with the Bad, Flint, and Cass rivers as its chief tributaries In primitive days Swan Creek, which flows into the Shiawassee not far below the mouth of the Flint, was of some importance as a waterway

The casual observer who sees the smaller streams in the droughts of August may question some of the statements which have been made concerning their navigation in former days, for instance, it has been related that in the early part of the last century one was able to get within thirty miles of Detroit by canoe by following up the Shiawassee River to its source in Genesee County It is quite possible that this involved a short portage between streams, but even so there is much evidence to support the assertion

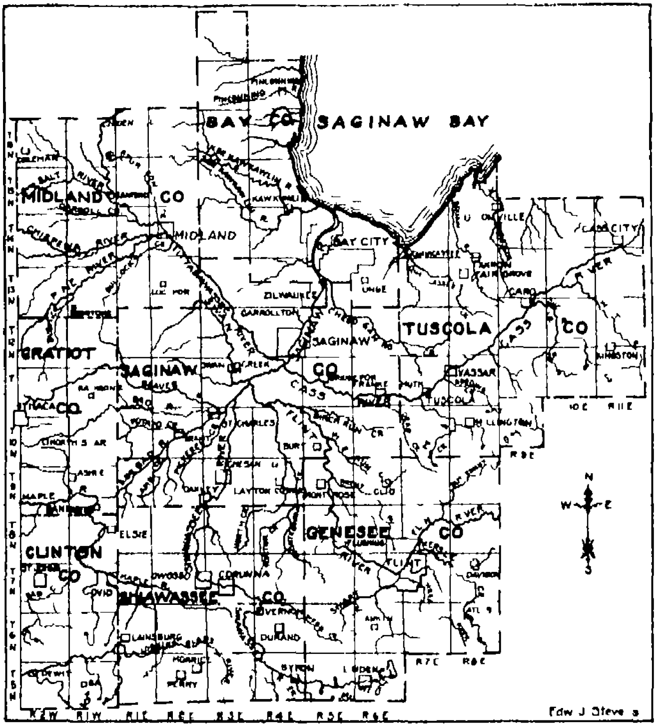
In this paper the designation "Saginaw District" covers not only the drainage basin, but also the bay of that name and some of the small rivers that empty into it Since the travel of the Indians centered at one place, with subsidiary stations at convenient or strategic points, Saginaw has been made the starting place for the studies of the several waterways which have been named

The locations of places and the courses of streams described in this paper can readily be found on the accompanying map (Map 1) For the preparation of the map I have to thank my friend, Mr Edward J Stevens, to whose kindness and technical skill I have been indebted on more than one occasion

SAGINAW RIVER AND BAY

The first recorded notices of the Saginaw country indicate that it was in the possession of the Chippewas, a large and important branch of the Algonquian family Their range was on both sides of Lake Huron to Sault Ste Marie, along the north and south shores of Lake Superior and later into Minnesota They were essentially a people of the woods and waters, and as a consequence of their environment the Great Lakes and streams flowing into them became their highways, and journeys of hundreds of miles by water were not uncommon

Their birch-bark canoes were models of beauty and utility and were used largely in their voyages over the lakes, whereas the dug-outs, patiently worked from a solid log, were an ordinary means of conveyance on the streams in addition to the lighter craft



MAP 1 Waterways of the Saginaw District, Michigan

The earliest white voyagers were familiar with the terrors of crossing Saginaw Bay, and today Harbor Beach, the great sheltered refuge, is not infrequently filled with vessels northbound, waiting for the choppy seas to go down before proceeding on their way What, then, must it have been to the Indian in his frail craft?

Schoolcraft says [3] "In order to cross Saganaw Bay in safety in a canoe, it is necessary to pass up the eastern shore from Point aux Barques to Point aux Chenes [now called Oak Point], a distance of eighteen miles Here, if the lake be calm, the voyageur crosses by a stretch of twenty miles to the opposite shore, with the advantage of landing on the island of Shawangunk [Charity], should a storm overtake him in the center of the Bay, which is frequently the case" He also mentions the fact that accidents caused by sudden squalls often happened at this crossing

The course was almost due west, with the landing place at Gravelly Point, now called Point Lookout [4] Saginaw Bay is, officially, that part of Lake Huron west and south of a line drawn from the Tawas Point Light to the Point Aux Barques Light from here the distance to the mouth of the Au Sable River by a direct line is about forty miles To gain this distance, an Indian in his canoe paddled nearly a hundred miles, for he crossed the bay, as noted, and followed the shore, keeping within easy reach of it

Should he be on his way from the lower end of Lake Huron to the Saginaw River, he would not cross to Gravelly Point, but would coast along the eastern shore of the bay If the Au Gras River, the Rifle, or the Kawkawlin was his objective, he would cross to Gravelly Point

The Rifle is a cold swift stream having its sources in the infertile sand plains of Ogemaw County, it was difficult to canoe,[5] although carrying a good volume of water, whereas the Kawkawlin, a sluggish stream passing through a more arable territory, was a favored highway, as the numerous prehistoric remains attest

Entering the Saginaw River, our primitive navigator passed the sand bluff at West Bay City's present site, finding little current and an unobstructed channel through the great marsh to the high ground where now is the city of Saginaw

THE TITTABAWASSEE AND ITS TRIBUTARIES

Tittabawassee River has its sources in the pine lands of Ogemaw County It flowed through wide belts of that timber, but along its

[3] Schoolcraft, Henry R *Narrative Journal of Travels from Detroit Northwest through the Great Chain of American Lakes to the Sources of the Mississippi River in the Year 1820* (Albany 1821) p 98

[4] Official Lake Chart Lakes Erie and Ontario, with the southern parts of Lake Huron and Georgian Bay Navy Department, Washington 1895

[5] Dustin Fred *Report on Indian Earthworks in Ogemaw County Michigan* (Scientific Publication No 1 Cranbrook Institute of Science, Bloomfield Hills, Michigan, 1932)

lower course especially, through extensive forests of hardwood covering a very fertile soil Game of all kinds, wild fruits, nuts, fish, and other edible products were in abundance, so that from the mouth of the Tobacco River to Saginaw the stream was dotted with Indian villages, and their remains not only have astonished the archaeologist by their number and extent, but have added richly to his stores of relics of the former inhabitants [6]

The first branch of importance above the junction of the two rivers at Saginaw is the Chippewa, which empties into the Tittabawassee at Midland after receiving the Pine a mile or less above its mouth The former has its sources in small lakes in Isabella and Mecosta counties In Indian days canoes passed up its waters to Mount Pleasant or farther A few years ago two young men canoed from that city to Saginaw They reported a difficult passage in some places, but it is to be remembered that before the forests were cut off, the summer flow of the streams was much greater than at present

The Pine River also had its beginnings in Isabella and Mecosta counties It was an Indian waterway probably as far as Riverdale in Montcalm County

The next tributary of importance is the Salt River, previously noted It rises in Isabella County In lumbering days much pine was floated down to the Tittabawassee, and on that river below the mouth of the Salt River experimental work in sinking a salt well was begun under the direction of Dr Douglass Houghton in 1838

The Salt River could be navigated by canoes for some miles above its mouth, and Indian artifacts have been collected along its course far up toward its headwaters

In the days of the glory of the pine, 'Sixteen' in Midland County (now called Edenville) was a noted place The Tobacco River entered the Tittabawassee here, where active lumbering operations had their headquarters From the relics since collected it seems evident that the red men found it a convenient camping ground as well as a more or less permanent residence Canoes passed up the Tobacco as far as Clare, and quite probably to Farwell I have collected chert chips on the river bank at the Clare dam, and others have found arrow points there The Cedar River, which joins the Tobacco at Beaverton, was also navigable for several miles

[6] Dustin Fred, "Some Ancient Village Sites in Saginaw County Michigan, *Pap Mich Acad Sci Arts and Letters*, 12 (1929) 75–93. 1930

There is little doubt that the Tittabawassee was used as a waterway as far as Ogemaw County The Mackinaw Trail touched its headwaters at several places and followed its lower course to Saginaw

THE SHIAWASSEE AND ITS TRIBUTARIES

From its junction with the Tittabawassee the Shiawassee winds its way southward through a great marsh twenty miles long and six miles wide at its greatest breadth, through this marsh it receives all its tributaries, which were Indian waterways Just below Chesaning quick water begins, from this point to Byron and above there were alternating rapids and stretches of dead water, but now the river is obstructed by several dams, the one farthest downstream is at Chesaning

In the lower section of the great marsh the stream spreads out into a shallow sheet of water locally known as Shiawassee Lake, filled with rushes, water grass, and wild rice In early days it swarmed with pike, large-mouth black bass, and multitudes of less esteemed fish, and was the nesting place of myriads of ducks and other waterfowl On the driest portions of the marsh tall, coarse grass grew to a height of ten feet or more One dry season forty years ago I was caught in this tangle of vegetation by a prairie fire Only one who has had the experience can realize the difficulty of making his way through it with raging flames close at hand and the friendly river all too far away In autumn it is no infrequent sight to see from Saginaw a brightly lighted sky southward, as of a burning city, but this has been lessened by the diking and cultivation of about eight thousand acres comprising what is known as "The Prairie Farm" On this marsh, covering approximately a hundred square miles, there is scarcely a change of contour line [7] aside from those created by the dikes The interval on the topographic sheets of the Geological Survey of the district is only five feet

As to the early navigation and its improvement by the white settlers, the following extract from a history of Shiawassee and Clinton counties [8] is of interest "The company commenced the work in 1837, and continued it during that and the following

[7] U S Geological Survey, Topography State of Michigan, Saginaw Quadrangle (Washington, 1919)

[8] Ellis, Franklin, *History of Shiawassee and Clinton Counties, Michigan* (D W Ensign & Co, Philadelphia, 1880), p 31

year, expending several thousand dollars on the river in removing obstructions (principally between Chesaning and the mouth of Bad River), erecting dams, and constructing tow-paths above Chesaning The river was thus made navigable for flat-bottomed boats or scows, several of which were built with foot-boards on each side, on which men walked forward and aft in 'poling' the craft up the stream This poling process was employed on that part of the river which is below Chesaning, but above that place horses were used At some points the tow-path was made on the east side of the stream, and at others on the west Larger boats were afterwards used for floating products down the river from Owosso One 'Durham' boat, built at that place carried a cargo of two hundred barrels of flour from Owosso to Saginaw "

Later on a lock was constructed at Chesaning, and other improvements were made, but nothing now remains

In 1887 a schooner fifty-one feet long of seventeen-foot beam and four-foot depth was built at Oakley near the south line of Saginaw County * After the work was well under way and the planking on, an examination of the river below Chesaning revealed the fact that about four miles of the channel above the mouth of the Bad River was completely filled with flood wood, and that instead of a single navigable stream, there were three or four small creeks winding about through the obstructions As a consequence, the little vessel was loaded on sleighs and hauled by four teams to St Charles, where it was finished and launched I have not been able to learn when the obstructions began, but they still remain

The Shiawassee was a favorite Indian waterway Along its course on rich bottom lands were numerous cornfields On the bluffs and benches villages were located At Owosso, Grand Traverse of the French canoeman, the Great Trail from Detroit to Saginaw Bay crossed the river and followed it down to Chesaning, "Great Rock," where a large limestone boulder lay in the river bed, and three quarters of a mile eastward another great rock mass of igneous origin stood in the woods, both objects of mild veneration

Cass River enters the Shiawassee through the lower end of the great marsh about three quarters of a mile above where it unites with the Tittabawassee Its sources are in Sanilac and Huron coun-

* Dustin, Fred "A Reminder of the Old Lumber Days, When Ships Came In" *The Saginaw Courier Herald*, July 31, 1910

ties, the North and South branches joining in Tuscola County, a mile south of Cass City

From its mouth to the Town Line Road in Saginaw County it is sluggish, with a fair depth of water, from this point to the Dixie Highway it becomes shallow, running over a sandy bottom with a few short rifts Onward to Tuscola Village there are a number of rapids with gravel and boulders forming the river bed From Tuscola to a point two or three miles below the Grand Trunk Railroad bridge near Cass City the river was a succession of rifts and still water, from here for about nine miles upstream the bed is sandstone Near the lower end of this outcrop there is a stratum of argillaceous limestone, which the Indians used for making pipes [10] Farther up near the Grand Trunk bridge I have seen blocks of similar rock, but did not observe whether there was an outcrop of it there

The Cass is fed by several living streams entering on the south side, which have their sources in small lakes At present boating is not feasible to where the rock bottom begins except in high water, although originally it was a waterway from the western edge of Sanilac County to its mouth

A trail on each side of this river followed it from not far above its mouth to Indian Rapids in Sanilac County, with important crossings below the East Street bridge near Saginaw, at Bridgeport, Tuscola, and Caro

The Flint River and Swan Creek enter the Shiawassee five or six miles above the mouth of the Cass from the east and west respectively, Swan Creek a few rods below the Flint

Swan Creek has its beginnings in Saginaw and Midland counties, and although now insignificant in its summer flow, in the spring is often a torrent which spreads over its narrow valley to a depth of eight or ten feet It parallels the Tittabawassee at an average distance of three miles The lower half of its course is bordered by a narrow marsh on each side, which widens and merges in the great Shiawassee marsh three miles from its outlet

Indian remains, beginning at the first high land above the great marsh and extending well up into Midland County, are numerous, no fewer than eight village sites have been located [11]

[10] Rominger, C , *Geology of the Lower Peninsula, Geol. Surv Mich* (New York, 1876), 3, Part I, 104

[11] See map cited in note 7

There was no section of the whole district where game was more plentiful than in the immediate vicinity of Swan Creek, and during the canoeing season the aborigines living thereabouts whose affairs or inclinations took them up the Shiawassee found a nearer and more convenient route than the one down the Tittabawassee A few years ago this creek was dredged to the Midland County line, with improvement in the boating Forty years ago while hunting in the woods bordering the great marsh, I walked for many rods on logs that filled its bed near the edge of the timber and a long distance out on the open prairie The season was unusually dry, and there did not seem to be a drop of water in the old channel, but above the woods there were several miles of deep water The logs were the remnants of lumber days when much timber, especially pine and oak, was floated down its waters

The lower six miles of the Flint River are through the great marsh, but it is not until Genesee County is entered that rapids begin At Flushing it flows over a rock outcrop, and the rapids increase as it is ascended At Flint the Detroit and Saginaw Trail crossed, a branch led north to Tuscola Kearsley Creek and Thread River flowed into the larger stream at Flint, where it made a great bend to the north toward its sources in Lapeer County

As a highway for pioneer settlers, the Flint River has perhaps figured more in the annals of Saginaw than any other The first road opened from Detroit to Flint followed the Indian trail, but it was several years before it was made passable to Saginaw As a result, many of the earliest comers to that place secured boats or canoes at Flint and made the two days' trip to the small village clustered around the stockade called Fort Saginaw

Some of the historical sketches have been put into print and among them we find "A Trip from Detroit to the Saginaw Valley over Fifty Years Ago," by William R McCormick [13] At that particular time the trip took three days, since the water was very low and the "rafts" or "flood woods," as they were called, formed long and difficult obstructions Later, when these rafts were opened, with a fair stage of water the time was shortened a day

Quoting from McCormick's account, he says "We had passed all the rapids and the river now became deeper, and we went on

[13] *Michigan Pioneer Collections, Report of the Pioneer Society of the State of Michigan*, 7 (1884) 271-277 Quotation on pp 273-274

very well and soon arrived at the Driftwoods These driftwoods had been accumulating for ages, having been brought down by the spring freshets The river was so obstructed from the bottom to five or six feet above the water, and so tight was it jammed together, that a muskrat could scarcely find his way through it The Indians had a portage around it where they drew their canoes These floodwoods were about forty rods long We then started down the river, and had not proceeded over a mile when we came to the second floodwood This floodwood was about twenty rods long We then proceeded down the river for about half a mile, when we came to the third and last floodwood ten rods long [This was near the present East Street bridge] Close by was an Indian village where they had their cornfields The floodwoods were removed by the lumbermen of the Saginaw valley in 1843"

These flood woods occurred also on the Cass and possibly on the Tittabawassee, although I have no record of them on the latter stream They occasionally changed the courses of the rivers, a notable example of which can be seen about eighty rods west of the Dixie Highway on the Cass Many years ago an aged Indian came to that locality on a visit, and remarked that the river was not where it should be He indicated its course almost due west along the foot of a bluff on the south bank, whereas it now makes a sharp bend to the north until it strikes a clay bluff which forces it southwest to a point where it again touches the high ground on the south and meets its former bed The part thus cut off is a clearly defined channel a mile long, usually with some water in it The old Indian said when he was a boy the river ran through this ravine

We now come to our last river, the Bad Geologists say that, long ago in geological time, Lake Huron, then much higher than now, emptied its waters into Lake Michigan by way of the Maple and Grand rivers [13] The southwestern lobe of this ancient lake had its shore not far from the principal meridian which forms the boundary between Saginaw and Gratiot counties On the headwaters of the Maple, northwest of Bannister in Gratiot County, we look across a broad, shallow valley, in places over a mile wide

To one having some knowledge of the geological history of the

[13] Leverett Frank and Taylor, Frank B, *The Pleistocene of Indiana and Michigan and the History of the Great Lakes, U S Geol Surv, Mon 53* (Washington, 1915)

region a wonderful page in Nature's Book lies open before him In his mind's eye he sees to the east and northeast a vast lake at his feet a mighty flood of water pours southwestward, but here the picture fades, and it remains for the specialist in Earth's history to complete the story The great lake has receded to the present waters of Saginaw Bay and has its outlet northeastward to the sea through the St Lawrence, and the little Maple River flowing along this great channel "is lost on the swampy floor throughout its whole course from two miles northwest of Bannister"

An examination of the Elsie sheet of the topographic survey of this vicinity[14] reveals some interesting facts It is observed that the South Branch of the Bad River apparently ends its winding course on the line between Sections 23 and 24 in Elba Township, Gratiot County, less than two miles from a great bend in the Maple to the southwest This bend has been cut off by dredging a straight new channel on the west side of the Ann Arbor Railroad Where the crooked course of the Bad ends on the map, it has been straightened by dredging ditches west and south following section and quarter lines almost, if not to, the old channel of the Maple

The divide between the two streams is hardly perceptible, and in driving across it we suddenly find water flowing west whereas but a few minutes before we saw it running east Before the land was cleared and ditched, it was possible in very high water to pass from river to river in a canoe Thus a continuous waterway existed in the early part of the last century and before from Lake Huron to Lake Michigan

The four rivers, Saginaw, Bad, Maple, and Grand, constituted an important waterway across Michigan It was paralleled by the Saginaw Bay and Lake Michigan Trail, and an old map[15] has a distinctly marked portage between the Bad and the Maple, so that it is not to be understood that a continuous waterway existed at all times and seasons, but there were intermittent periods of complete navigation

In his paper, "Indian Modes and Paths of Travel in Michigan Waterways,"[16] Dr W B Hinsdale, of the University of Michigan,

[14] U S Geological Survey, Topography, State of Michigan, Elsie Quadrangle (Washington 1918)

[15] Franquelin's map of the eastern portion of what is now the United States (Paris, 1688) See *Pap Mich Acad Sci Arts and Letters*, 7 (1926) 20, note 16 1927

[16] *Pap Mich Acad Sci, Arts and Letters*, 7 (1926) 16 1927

says "Canoes could ascend the Grand to Lyons, Ionia County, take the Maple and approach within the breadth of a half-township the Shiawassee," whereby it was possible to ascend to its headwaters or to descend to Saginaw Bay

The North Branch of the Bad rises in Gratiot County near Ithaca In lumbering days great numbers of pine logs were floated down to St Charles where they were sawed Here the North and South branches unite, and Beaver Creek, another lumbering stream rising only two miles north of the headwaters of the North Branch, enters just below the forks At one time a regular steamer service was maintained between St Charles and Saginaw The last time I was at the mouth of the Bad River, the rotting hulk of the *Signet*, which blew up there sixty or more years ago, was still visible

There is an incident concerning the navigation of the Bad River, now almost forgotten, for it took place nearly a hundred years ago During the 'thirties of the last century a wild craze for "internal improvements" afflicted the people of Michigan, corresponding to our recent craze for fabulously expensive highways As a result, many projects for improving navigation were put forward The state legislature approved of them all and undertook the construction of a number, one of the most ambitious being the Saginaw and Grand River Canal Contracts were let and the work started speedily, but the bubble burst

A historian of fifty years ago [17] says "It was not to be expected that the contractor for this work would be able or willing to prosecute it without prompt payment on the part of the State, which, failing to meet its engagements was averred by the contractor as the cause of the work being abandoned This occurred in June 1839 Most of the work required on one section of the canal has been completed There is now on the line several thousand feet of plank and timber intended for the locks and dams A great portion of the timber is framed, and will, from its exposed condition, decay very rapidly The timbers mentioned remained to rot on the ground, and the remnants of some of them have been visible in the town of Chapin, Saginaw County, in quite recent years"

Today as the traveler from St Charles to Brant crosses the South Branch, he will note on his left a line of straight river about

[17] Page 30 of work cited in note 8

three quarters of a mile long with the retaining walls and old timbers This is the portion of the Saginaw and Grand River Canal that was completed, and stands as a monument of folly and fatuity

As late as 1880 a small steamer operated on the Maple River between Maple Rapids in Clinton County to Bridgeville in Gratiot County, but was discontinued soon after, thus ending navigation on that stream

It has been truly said that man or beast having a more or less distant objective will follow the lines of least resistance This may be qualified at times, since occasionally it is more desirable to cross a hill directly than to go around it, time and distance being saved by such a course Likewise a portage between streams or across great bends might save time if not labor So far as is known, there were few portages in the Saginaw District and no cut-offs, but it was possible to pass readily from the waters of the Saginaw to the waters of the Muskegon,[18] or possibly from the Shiawassee to the Huron River

SUPPLEMENT

DEFINITIONS OF INDIAN NAMES OF STREAMS OF THE SAGINAW DISTRICT

It seems fortunate that in the Saginaw District so many Indian names were bestowed on its streams and places, which, though corrupted and in some cases almost lost in bad spelling,[19] perpetuate the memory of the red man as well as give a significance and character that our meaningless names do not approach It is believed that the names and definitions following illustrate the appropriateness of the aboriginal designations In a few cases the authority for a definition is given Some of the Indian names are no longer used, but English translations have been substituted

[18] See page 16 of article cited in note 15

[19] The difficulties involved in defining Indian names will be readily observed in the following note from Schoolcraft Henry R *Information Respecting the History, Condition and Prospects of the Indians of the United States* (Philadelphia, 1854), Part II, p 465

"The crow was known among different bands of Chippewa by apparently unrelated names in some cases for instance at Sault Ste Marie it was On-daig, at Grand Traverse Bay, Kah-gah-ge, at Mackinaw Aun-daig at Saginaw, Kah-kah-ge '

Bad — Maw tchi Se-be ' bad river was the Indian name for the South Branch, Mis-a bos, ' white rabbit, ' for the North Branch Wau po Se-be, "swan river ' now called Potato Creek, flows into the South Branch a mile east of Brant Center It appears on Farmer s map of Michigan [20]

Bear — The English rendering of the name of a small stream flowing into the Shiawassee in Section 14 St Charles Township The Indians called this creek, Maw kwa Se-be, "bear river

Cass — Na-da way, I bring him in a canoe, ' referring to some event associated with the river It was also called by the Indians 'the river of the Hurons ' owing to the fact that a band of Hurons lived for some period at its head waters and about the forks near Cass City

Cheboyganing - "The place of the big pipe according to Baraga s dictionary [21] but an educated Ottawa Indian, I S Wakefield, of Grandville, Michigan, has informed me that Cheboygan ' means ' a sound like the passing of a needle through fabric Dr Melvin R Gilmore of the University of Michigan, and Edward J Stevens of Kalamazoo, Michigan, also disagree with Baraga's translation Mr Stevens has made a study of Indian place names in this state, and Dr Gilmore has secured considerable direct information from the Indians themselves "Cheboygan" illustrates the differences occurring among those whom we may assume to be authorities

Flint - Pe-on-i-go Se-be, flint river, or Pe-on i-go-ing Se-be, "flint-place river Authority Daniel Wheaton a full blood educated Indian of the Chippewa tribe, born in Saginaw County where he lived all his life

Kawkawlin — A corruption of Kaw kaw-ing, ' crow place According to William R McCormick [22] Kawkawlin was called by the Indians O kaw-waw-ning the meaning of which is pickerel river ' Andrew J Blackbird [23] gives *o-gaw* as the name for pickerel The *ing* means ' place ' George Wheaton, son of Daniel Wheaton, has informed me that Kawkawlin or, more accurately, Kawkawing, means ' crow place

Misteguay — A corruption of Me-she-say, "wild turkey " This creek rises in Shiawassee County and enters the Flint River five miles above its mouth

Pinconning — A name commonly supposed to be a corruption of the Indian designation meaning ' the place of the wild potato " This is not the potato of the market, but a small tuber which has been called by that name

Dr Melvin R. Gilmore says of this word [24] "In the Chippewa language the word *pin* is a generic term signifying tuber,' and is applied to many tuberous growths ' In this case it designates the *Apios tuberosa* Moench, commonly known as rosary root, of which great quantities grew along the

[20] Farmer, John, *Map of the Surveyed Part of Michigan* (New York, 1837)

[21] Baraga, Rev Frederic *A Dictionary of the Otchipwe Language, Explained in English* (Cincinnati, 1853)

[22] Page 277 of work cited in note 12

[23] *History of the Ottawa and Chippewa Indians of Michigan A Grammar of Their Language and Personal and Family History of the Author* (Ypsilanti, Michigan, 1887)

[24] *Pap Mich Acad Sci , Arts and Letters*, 17 (1932) 133 134 1933

banks of Pinconning Creek and were harvested by the Indians ' For this reason states Dr Gilmore, they called this locality *Pin-kaning*, which is to say, the place of the *pin*

Rifle — Me-sag-wisk, the name for Rifle River as used in the Treaty of Saginaw in 1819[38] I have been unable to find its English equivalent

Saginaw — A corruption of the Chippewa phrase, Saug-ee an te-nah ke-wat, where the Sauks (Saugee) were It was easily shortened to Saugeantenah or Saugenah Authority Daniel Wheaton

Sebewaing A corruption of Se-be-weus literally 'little river *Sebe* means ' river *wens* is a diminutive ending

Shiawassee A corruption of O-zhaw wask kwaw Se-be ' green river easily corrupted to Shiawassee Authority Daniel Wheaton

Swan – An erroneous rendering of Sho-sheb Se-be (e s pronounced as in *eat*) ' duck creek '

Tittabawassee — A corruption and shortening of an Indian phrase signifying the river that follows the shore ' Has been spelled in different ways variations of the present rendering

SAGINAW, MICHIGAN

[38] Royce Charles C , *Indian Land Cessions in the United States Eighteenth Annual Report of the Bureau of American Ethnology* (Washington, 1899), Part 2, 698

THE ARIKARA METHOD OF PREPARING A DOG FOR A FEAST

MELVIN R. GILMORE

AMONG the Arikara the serving of dog meat is proper for a feast on some high day, as the serving of turkey is with us at Thanksgiving and Christmas. The flesh of young dogs is preferred. It was my good fortune to be able to observe, on Saturday, July 24, 1926, the killing, dressing, and cooking of a dog for a feast of the Buffalo Society, one of the eight mystic fraternities of the Arikara tribe concerned with socio-religious observances. An old man named Kunuȟ-wahat had invited his fellow-members to a feast on the occasion of the celebration of the mysteries of the Holy Grandmother Cedar Tree.

The Arikara methods of killing and butchering a dog are different from those of other tribes. The dog selected on this occasion was not yet full grown. It was mostly white, but had a few splotches of color. The work of preparing it devolved upon the wife of the host. Seizing the dog by the hind legs Mrs. Kunuȟ-wahat whirled it several times in a vertical circle and then struck its back and head with great force upon the ground. While it was stunned she placed her left foot upon its neck, resting all her weight on it, thereby preventing the recovery of respiration until she was sure it was dead. In reply to a question she explained that swinging the dog around was an act of mercy to make him dizzy in order to lessen the pain as he hit the ground. The only sound from the dog was a little whimper as the swinging started.

After killing the dog Mrs. Kunuȟ-wahat kindled a fire and laid the body on it. Watching it closely, she continually turned it about until the hair was all singed off. By this means the skin was blistered till it was puffed out all over the body.[1] She then washed off the singed hair, using plenty of water to make the carcass entirely clean.

[1] I have been told that this method of removing the hair is employed by the country people of France when they butcher a hog.

before butchering it As she slit open the body from throat to tail she was careful to keep the vents closed in order to prevent soiling the meat She removed all the viscera and washed out the trunk Then she cut off the head and tail, which were discarded with the viscera

The dressed carcass was divided into portions in accordance with a well-established tradition These portions are the two fore-quarters, the two hindquarters, the two sets of ribs, the cervical and dorsal vertebrae with adjacent bones and muscles between the shoulders, and the lumbar vertebrae with the bones and muscles which form the pelvic girdle

The Arikara cut up the carcass of a dog with the skin still upon it, as is the case when white people butcher a hog Mrs Kunuh̆wahat said in explanation "The skin is too rich to lose"

There is nothing distinctive in the last steps of the preparation for the feast As the water is being heated in a kettle the portions of the meat are cut into small pieces, washed for the final time, and then put into the pot to boil When the cooking is completed the meat is ready to serve

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THE PLIGHT OF LIVING SCALPED INDIANS

MELVIN R. GILMORE

THE practice of scalping, the taking of a small patch of skin from the top of a slain enemy's head as a battle trophy, sometimes, though very rarely, resulted in the scalping of a man who was not dead, but who in the confusion of battle appeared so from having been knocked unconscious by a blow on the head. No warrior would knowingly remove the scalp of a living man, but if he found an apparently dead enemy on the field of battle he might take the scalp.

In the Arikara language the term applied to a living man who had been scalped by mistake is *tsohonuhu*. Such a man was most unfortunate, for by tribal custom he could not return to take his place among living men. On recovering from his wounds he had to live in solitude. He made a shelter for himself in some isolated place far away from the villages and the customary resorts of his people. He cunningly concealed his dwelling to keep it from being seen by anyone who chanced to pass by. Since he was regarded as a dead man and a ghost, the sight of him would have been a shock and an offense to the living.

A tsohonúhu confined most of his movements to the nighttime or the dusk of evening, in order to lessen the risk of being seen; if he did move about in broad daylight it was only at times when he had assured himself by scouting that no one was in the vicinity. Being absolutely without human companionship, he was separated as if by death from the community of the living. He had to take care of himself as best he could, unaided by friends or relatives. He had to find and prepare his own food, contrive his own raiment and footgear, and manufacture his own utensils and weapons. Any manner of communication with him was likely to bring bad luck.

This paper has to do with the plight of two living scalped men. When the first one whose story is recounted here went away to war he left at home a wife and a little boy, both very dear to him, but after he had lost his scalp he was irrevocably separated from them. Because of his deep love for his wife and child he could not resist,

however, the desire to be near them, although custom and religious practice made it impossible for him to go openly into the village and make himself known to them

His wife mourned for him very deeply and sincerely Often she would go away from her people and the village that she might be alone in the silence of the hills at evening and undisturbed while wailing and mourning Her husband, as he hovered about outside the village, concealed by the twilight and the darkness, heard her crying many times, yet restrained himself from approaching her But a time came when his longing overpowered him and very quietly, so as not to startle her, he came near and spoke in a low voice On hearing him she supposed him to be a suitor who had come to court her She tried to repulse him "I do not wish to talk with you Do you not understand that I am grieving for my husband who is dead, and that I cannot think of any other man?" Then he very gently made her realize that it was her husband who was speaking to her, that a mysterious power had come to him after his death on the battlefield and resuscitated him, but because the enemy had scalped him he was forever separated from her and their child and from all the living He told her that for this reason he could not come to her, that for him to have any connection with the living was contrary to the will of the holy mysterious beings who had revived him But he said his love and longing for her and for their child were so great that his feelings had compelled him to come often at night to a place where he could sit overlooking the village and think of his dear ones

After he had thus made himself known and after they had conversed for a while, the young woman returned home to the village and the tsohonuñu went back to his cave Before they parted they agreed to meet again in similar manner, and to take great care that they should not be discovered By means of these meetings the man kept informed concerning affairs among the people After a time famine came upon the village, and he was anxious about the welfare of his child When his wife informed him of the situation he told her of his anxiety and promised to supply her with provisions for their need if she could keep the matter secret From time to time he brought supplies for her to their meeting place

Her father and mother noticed that she was obtaining food and concluded that a suitor was making the gifts Her father was con-

tent and said "Our daughter is a widow, but she will now have a husband to provide for her and our grandchild It is well" So matters continued for a while, but the husband replied to entreaties "I cannot come home That is not permitted by the mysterious beings who resuscitated me Evil consequences would result if the requirement that I remain apart should be broken" Finally he sent provisions to his own parents also, and eagle feathers to his father They, too, concluded that the gifts came from a suitor and were not displeased They thought that their daughter-in-law would soon have a husband, with security for herself and her child

The secret meetings continued, and the feeling of strangeness that was due to his abnormal condition gradually wore off a little The intimacy which they had experienced in their earlier, happier days now returned to them One evening as they sat and talked together the wife asked to be allowed to see the scar of the wound on his head As he complied, their tender feelings for each other became so great that their restraint was wholly overcome and they joined in conjugal embrace Then realization came to him He felt stricken, and said with remorse "Now we should not have done this I think that tomorrow I must die If tomorrow night I do not come here to you it will be because of my death You will then go to the place of which I have told you, where I have been keeping myself since I was resuscitated by the supernatural powers You will find me dead or dying There I have all manner of supplies These you will divide with my relatives"

Near morning they parted, after he had given her careful instructions how to find his cave He told her he would leave broken branches and twigs to mark the way He gave her these directions "The place is in the face of a steep hillside You will find on it stones which serve as steps to mount to the entrance of the cave As you ascend upon these stones you will come to a clump of sagebrush When you pass it you will see, a little higher up, a large root that seems to protrude out of the hillside You will pull upon this root It will open my door Then you will enter On each side of the entrance there is a storage place In the bins you will find all kinds of supplies, there are food, clothing, robes, weapons, war bonnets, and many other things of use and value which I have seized from enemies"

The next evening the young woman came again to the rendez-

vous where she and her husband had been meeting, but he was not there She waited in the hope that he might yet come Through the long night she stayed, but he did not appear She recalled the foreboding words he had spoken to her at their last meeting, when he had told her he expected to have to die because of having broken the restrictions imposed upon him As the night wore on she was convinced that she would never see him again in life She returned home before dawn and took steps to carry out his last instructions She rekindled the fire and prepared food Then she summoned her own parents and his to come and have breakfast with her She explained that she had something to tell them They expected her to announce her engagement to the donor of the food and other supplies, for they knew nothing of the fate of the husband who had been lost in battle

What she had to say was far different from that which they had been anticipating She startled them all by telling them that she had been visiting her husband and that he was a tsohonuȟu, who could have no relations with the living She recounted the occurrences of their last meeting and repeated the words he had spoken at that time Then she concluded "We must now go out there I am sure he is dead He told me that he expected to die and that, if he failed to meet me last night, it would be because he was dead"

Thereupon the young woman guided them to the cliff which her husband had described On approaching the cave they saw the man's feet extending from the entrance, where he had died as he was going into the cave They lifted up the body, carried it inside, and laid it upon the bed Then they sat down upon the ground and wailed for him After the mourning ceremony the young man's father spoke "We will leave him here We will not take him to be buried in the cemetery of the village This was his home It is inside the earth Mother Earth has received him back again We will leave him here to her protection"

Before departing the wife told them about the storage bins and the goods which he had directed her to divide among them After carrying out his wishes they sealed up the entrance to the cave and went home

"His bones must be there yet," said my informant when he told me the story The time of this event was very many years ago, and the location was somewhere near the Missouri River, much farther

downstream than the present home of the Arikara tribe, to which they came in their later migration

Another tsohonuhu lived among the Arikara within the period during which the tribe has occupied its present territory The location of his cave was discovered about forty or fifty years ago It is on the land of Mr William Deane, about two miles south of his house, and faces the Missouri River I visited it in August, 1932, with Mr Deane as my guide The roof had fallen in long ago, and erosion and weathering have left their marks upon the face of the bluff, which is partly overgrown by vegetation A scraggly growth of chokeberries, buffalo berries, and other shrubs surrounds it It was twelve to fifteen feet wide and fifteen to eighteen feet long In his boyhood and youth Mr Deane had often heard from his people the story of the wretched man He had seen the cave while it was still in nearly the same condition in which it had been abandoned From his description and from the ruins I was able to visualize it as it must have been during the time of its occupation

The story, as Mr Deane had heard it from older members of his tribe, was that a certain Arikara warrior who had been wounded in battle had fallen unconscious and, while lying in a deep swoon, apparently dead, had been discovered by the enemy On regaining consciousness in the night, he found, to his horror, that he had been scalped and hence could not return to his people for help With great effort he dragged himself away and reached the river, where he slaked his feverish thirst Then he hid and remained in concealment until he felt his strength gradually returning Thanks to a strong constitution, he fully recovered his health, whereupon he sought refuge in the Little Bad Lands on the north side of the Missouri River below the point where Elbowoods is now, the location of the Fort Berthold Indian Agency In these desolate, craggy hills he found the cave which he fitted for his abode From springs no great distance away, at the foot of the bluffs, he obtained water for drinking and cooking The smoke from his fireplace was drawn away through a fissure concealed among the rocks and earth and overgrowth of shrubbery, so that there was slight risk of detection by chance passers-by By having only a little fire, and that only at night or after twilight had fallen, he lessened the chances that the smoke would betray his hiding place

After the battle, surviving comrades who had noted the place

where they had seen him stricken down and, as they supposed, slain, returned with some of his relatives to recover the body for burial They could not find it, although they searched a large area Some time later the dogs of the village frequently were heard barking at night, and in the morning strips of meat would be missing from the drying poles The circumstances led the people to suspect that the victim of the battlefield had had the misfortune to become a tsohonuȟu, that the barking of the dogs had been caused by his coming into the village, and that it was he who had helped himself to the strips of meat They thought that he must have found shelter somewhere in the rough, broken Little Bad Lands, which lay upstream not far away to the northwest, yet they never saw any trace of him Many years later, while his story was still being told among the tribe, but after all or most of the people who had known him were dead, the cave was found abandoned, though the remains of the occupant were never discovered The people think that death may have overtaken him in some unknown shelter

While the tsohonuȟu was still alive the Arikara had their winter quarters in the shelter of the thick woods on the flood plain of the river, about a half mile to the southeast of the cave in the bluff At intervals during the winter his grandmother came to a place on a terrace at the edge of this region of rugged hills and ravines where she thought he might possibly have found shelter Each time she brought parcels of food, moccasins, clothing, and other useful articles She would sit and wail and cry, and call her grandson's name aloud, telling him that she had brought these gifts, hoping that he might be somewhere within sound of her voice and thus would know that she had placed comforts there for him It could be noticed on the following days that the supplies were gone, so that the popular supposition that the young man was living and had a shelter somewhere in this wild region was strengthened

Since the winter village was so near it is probable that in the solitude of his cave he saw and heard much of the activities of his people, though none of them had ever seen any trace of him or heard any sound from him The pleasantly exciting winter sports went on near him, but he could have no more part in them than a ghost The water flowed from a copious spring a few hundred feet to the west of his cave and spread upon the flood plain of the river There it froze and provided a large area of smooth ice On moonlit evenings

the young people would come with their gliders made from buffalo ribs No doubt the tsohonuħu frequently heard their gleeful shouts and laughter Finally someone would shout "Come, it is time for us to go home The tsohonuħu may be somewhere about!" These words, too, must have reached his ears as the merrymakers trooped past in mock alarm hurrying toward the village

When the cave was first discovered it was in the condition in which its occupant had left it His fireplace was in the earthen floor His bed was on an earthen bench against the back wall at the northwest corner Some of his gear was stored in the northeast corner A bin for provisions had been excavated in the clay at one side of the entrance On the other side a reservoir for water had been dug in the clay It had been puddled with clay to make it impervious

At the present time the cave lies open to the sky because of the collapse of the roof There is no reminder of the tragic life which was lived in this remote and wild place Behind it rise the high gray buttes and bluffs, and groves and thickets of native fruits Before it, in the flood plain of the Missouri River, stretches the green forest of cottonwood, elm, ash, and other trees High in the blue sky above an eagle is frequently soaring

UNIVERSITY OF MICHIGAN

INDIAN TRADE IN MICHIGAN

FRANCES SEXTON HUGHES

INDIAN trade in Michigan has had two phases — one which preceded the coming of the European and one which was the result of his coming. Archaeology supplies evidence of the prehistoric commerce, whereas the relations of missionaries and travelers and the documents of the French and English colonies describe the post-European intercourse.

Michigan is particularly well suited for commerce. The Great Lakes and the inland waterways form arteries of travel which were used by the Indians as well as by the Europeans. Land routes also were numerous; archaeological investigation has shown that Michigan was covered by a network of trails. Many roads of the present day have been laid out upon this aboriginal pattern. The Indian trails not only were local routes, but were connected with, and often formed part of, a great network of trails reaching from the Atlantic seaboard to the Mississippi River. Dr. Wilbert B. Hinsdale of the Museum of Anthropology of the University of Michigan has mapped and described these routes in detail in his *Archaeological Atlas of Michigan*.

The evidence of Michigan's aboriginal commerce lies in the mounds, graves, and village sites not only within the state itself, but throughout the neighboring states, and even farther afield.

The bulk of the trading of which the mounds afford direct evidence centered about mineral products in the form of raw materials. The people living about Lake Superior must have found their abundant native copper a commodity in constant demand,[1] for the distribution of prehistoric copper artifacts is wide, and the Lake Superior region is assumed to be the source of most — if not all — of the mineral. One archaeologist[2] regards as evidence of such prehistoric intercourse with the regions to the south the many

[1] Shetrone, p. 64. (Complete bibliographical data are given at the end of this paper.)

[2] Moore, C. B., quoted by West, p. 64.

remains found in the mounds of the mid-western states, namely, shell implements and ornaments and raw material obtainable only on the Atlantic seaboard or on the Gulf Coast These things were traded for copper from the north Prehistoric copper artifacts have been found also from the Atlantic Coast to the Mississippi River and even farther to the west and southwest [3]

Evidences of trade with other regions have been found in Michigan Two pendants of sea shell were uncovered in a prehistoric grave on Mackinac Island,[4] and other finds of shells from the Gulf of Mexico have been frequent in Michigan burial mounds Artifacts of obsidian from the Rocky Mountains and of catlinite from Minnesota are occasionally come upon in the southern parts of the state [5] Arrowheads of the material from Flint Ridge in Ohio have been found here,[6] and plates of mica, probably from the Alleghany Mountains, have been taken from mounds near Grand Rapids [7]

Since "no definite medium of exchange has been identified in the prehistoric sites" [8] and since historic Indian tribes had not advanced beyond the stage of exchanging commodity for commodity, it is to be assumed that aboriginal commerce was conducted on the basis of barter

With the arrival of the Europeans native culture changed profoundly This change was brought about by commerce between the Indians and the newcomers

It was Michigan's fur supply which attracted the white men, the first of these to arrive were the French Explorer, trader, and missionary found Michigan rich in possibilities because it abounded in furs The Indians' first contact with Europeans was through the medium of trade and for the purpose of trade only

One of the first effects of European contact upon the native commerce of Michigan was an increase in the volume of trade The tribes of the neighboring regions are known to have had commercial relations with one another at the time of the coming of the French The Wyandots bartered the surplus of their maize fields with the surrounding tribes in exchange for fish [9] When the explorer Nicolet was sent from Quebec to make peace with the Winnebagos beyond

[3] Hinsdale, *Archaeological Atlas of Michigan*, p 12, Rau, p 355
[4] Nadaillac, p 173
[5] Rau, p 368
[6] Hinsdale, *Trade*, p 2
[7] Greenman, p 8
[8] Shetrone p 63
[9] Mason, p 587

Lake Huron, he found them trading with a tribe from farther west, which is thought to have been the Dakotas[10] The Potawatomi, living on the western shore of Lake Michigan at the time of Marquette's visit, were noted as traders[11] In contrast to this probably intermittent trade there grew up a commerce which attracted increasing numbers of Europeans, which became concentrated upon certain commodities, and which was continuous

Trade became specialized in furs The state was rich in many kinds of peltry, but the most valuable of all was the beaver For the Indian hunting had developed into something more than a means of obtaining food and material for clothing It was now a gainful occupation

To estimate the amount of fur traded by the Indians in Michigan is impossible, for this region was but a small part of a great Canadian province of which furs were the chief source of wealth, and estimates were made for the province as a whole The produce of the year 1698 was 181,150 furred animals, of which 106,000 were beavers[12] So hard was the trade pushed in the New World that the market became overstocked with beaver "When a new French trading company was formed in 1700, they took from the hands of the former company an accumulation of 600,000 pounds of beaver, paying only one-half the usual price French markets refused to buy, hence the directors burned three-fourths [of the supply] "[13]

As a result of the condition of the market the beaver trade was restricted in favor of the less lucrative commerce in other furs The Indians therefore were engaged in hunting elk, roebuck, otter, and black bear Since they were able to supply their wants by the trade carried on in these skins, they had by 1702 largely given up hunting the beaver[14]

The first trading for peltry between French and Indians was in the hands of the *coureurs de bois*[15] After prolonged experience in trading with these forest rovers at the Indian camps or hunting grounds, the natives began to be traders in their own right French policy required them to bring their furs to the great depots of ex-

[10] Johnson, pp 6–7, and note 14 p 6

[11] Jenks, p 1053

[12] Johnson, p 23

[13] *Ibid*, p 36, note

[14] *Ibid*, pp 36–37

[15] For a description of such trading see Blair, 1 263–265

change at Montreal and Three Rivers[16] Although many Indians sold their pelts to the lawless forest rovers, many others made journeys to these depots in eastern Canada, where great annual fairs were established Here they camped outside the cities, met the merchants, and bartered their furs for merchandise[17] When trading posts were established in Michigan during the second half of the seventeenth century, the long journey to the east became unnecessary[18]

Some tribes acted as middlemen between the French and the more distant native groups The trade which the Hurons had with other tribes brought them no little gain[19] The Potawatomi were intermediaries between the French and the tribes of inland Wisconsin[20] The Ottawas went away toward Keweenaw in the north and "sought to carry on trade with those tribes, who gave all their beaver robes for old knives, blunted awls, wretched nets, and kettles used until they were past service "[21]

The Indian played still another rôle, that of representative of the unlicensed French trader In order to save the overstocked fur market France forbade all trade in the upper country of Michigan at the end of the seventeenth century To attempt to stop this trade while the *coureurs de bois* roamed about at will was futile The traffic went on But the trader faced the problem of how to get his pelts to market and secure merchandise in exchange Since he dared not do it himself, he sent the Indian The latter was easily trained, he visited the colony and carried on all necessary transactions[22]

From the time of the arrival of the French in Michigan there was competition for the Indian trade, and as time passed this rivalry changed from individual to national There were two ways to attract the Indian trade to pay higher prices for peltries and to offer merchandise at lower prices, or, to reward the native with presents The latter method was used by the French, the former was the British policy The roving French traders bought the natives' good will and services with presents,[23] which were usually intoxicating liquors[24]

The Indians of the upper country who went annually to Mon-

[16] Johnson, p 5, *Jesuit Relations* 29 247
[17] Johnson, p 5, note
[18] *Ibid*, pp 15-16
[19] *Jesuit Relations*, 20 247
[20] Jenks p 1053
[21] Blair, 1 173-174
[22] Johnson p 29
[23] *Ibid*, p 54
[24] *Ibid* pp 25-27

treal often took rich and costly furs to the officers, and return presents were given at the king's expense[25] This innovation, which began as a gesture of generosity, came to be a necessity when British rivalry for the Indian trade began By 1670 the English had established on Hudson Bay a trading post which lured Indians and *coureurs de bois* from the French posts of northern Michigan, because the British paid more for peltries and offered cheaper goods[26] Later the British from New York came to Michigan with an abundance of cheap merchandise and quantities of rum to attract trade from the French In the valley of the St Joseph River, the region of trade for the Miami and Potawatomi, English influence grew strong, and the French found it difficult to hold the Indians' allegiance without continually loading them with presents[27] When Michigan became a British possession in 1759 this French practice cost the English dear in both goods and trouble[28]

It is commonly supposed that the Indian drove poor bargains in his early trading ventures, and so he did from the point of view of the European This quotation is typical "The French soon discovered that the Indian knew little of the value of fur and readily exchanged the costliest peltries for whatever tickled his fancy, even though it were a mere trifle So while the trade was in its infancy, an enormous profit accrued to the successful trader, at times a profit of from six to seven hundred per cent"[29] With practice, however, the natives improved, and in the eighteenth century "they had become excellent judges of the articles which were imported for them, and readily ascertained the lowest price for which they might be purchased"[30] Early in the association of the Indians with the French the beaver pelt became a medium of exchange and replaced trade by barter[31]

The Michigan Indians' first contact with European culture was at the French trading posts These were established at meeting places of the Indian and where the possibilities of trade made them worth while Sault Ste Marie was the first to assume importance, it was located where the Indians gathered for fishing and became the center of a widespreading fur trade[32] Of all the French trading

[25] Johnson, p 33
[26] *Ibid*, p 17
[27] *Ibid*, pp 61–62
[28] *Ibid*, p 65
[29] *Ibid*, pp 23–24
[30] *Ibid*, p 126
[31] *Ibid*, p 51, Swanton, p 448.
[32] *Johnson* p 15

posts that at Mackinac Island or Michilimackinac was the greatest It was located on the highway to Wisconsin and the wilderness beyond, and became a resting place for traders and a depot of exchange [33] The post at Detroit was established when English rivalry for the fur trade was becoming intense It was the entrance to the northern Michigan fur trade for those living to the south and southeast, and its strategic position was an important one to control Indians were enticed by any available means to settle at Detroit, until Michilimackinac was almost abandoned and some two thousand Hurons, Ottawas, and Potawatomi had assembled at the new post [34]

The advent of the European and the emphasis upon trade greatly modified native culture The gun replaced the bow and arrow The aboriginal tools of stone, bone, and wood gave way to steel hatchets and axes, steel knives, and iron hoes The crude pottery and the vessels of wood and bark were supplanted by copper and iron kettles European garments and cloth took the place of skin robes [35]

The whole pattern of native life was altered The emphasis placed upon the Indian's hunting and trading by the European was injurious to the native economy MacLeod says "It inhibited his settling down to Europeanized agricultural living As the supply of fur-bearing animals decreased with the progress of European settlements, the Indian village decreased in size, for the various families had to scatter in order to roam in hunting over wider and wider fields " [36]

Intertribal hostilities were engendered by the fur trade MacLeod writes of this "By the middle of the seventeenth century, the Iroquois had nearly killed off the beaver in their own country and could get relatively little fur to trade for European goods Consequently one of the principal objects of the Iroquois in warring upon and subduing the Algonkian tribes in the West — in what became the Northwest Territory of the United States — was to bring pressure on these tribes and oblige them to bring their furs to Albany to exchange for English goods, rather than to give them to the French traders of Canada To get to Albany these western tribes had to

[33] Johnson, p 16

[34] *Ibid*, pp 31–40, for a description of Indian life at the French trading posts see Blair, 1 282–283

[35] MacLeod, p 147, Wissler, pp 235–236

[36] MacLeod, pp 311–312

pass through the Iroquois country, and pay toll to the Iroquois for the passage, a valuable source of profit for the Iroquois "[17]

Subsequent to the Iroquois attempt to gain control of the trade of Michilimackinac the Ottawas and Hurons fought for commercial supremacy At the same time the tribes living about Detroit were at war[18]

In conclusion, then, we find that the Indians of Michigan engaged in commerce in aboriginal times, as archaeological investigation reveals After contact with the Europeans, however, trade became more conspicuous in native culture The emphasis placed upon trading by the white men changed the whole organization of aboriginal life The Indian passed from an economy based upon hunting for use to an economy based upon hunting in order to trade When game inevitably became scarce, hunting for the purpose of trading was no longer possible Here was a crisis The ancient economy had been abandoned, the later economy was played out There remained only one fate for the Indian cultural extinction He disappeared from the scene of post-European American culture

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A COMPARATIVE TAXONOMIC STUDY OF FORMS OF *COLLYBIA TUBEROSA* FR AND *COLLYBIA CIRRATA* FR *

JEAN D ARNOLD

KAUFFMAN (5) describes *Collybia tuberosa* Fr as small, 5–10 mm broad, convex to plane, whitish, often tinged reddish, stem slender, 2–4 cm long, 1 mm thick arising from a reddish brown or blackish, small sclerotium It grows gregariously upon decayed agarics or damp humus, and is reported as frequent throughout the state *Collybia cirrata* is 5 12 mm broad, plane or depressed, umbilicate or papillate, white or tinged reddish, stem 2 5 cm long, with a fibrillose, radicating base The gills and spores are practically alike in the two species *Collybia cirrata*, reported on decaying vegetable matter in the woods, is infrequent throughout the state

The main difference between the two species is, then, the production of a sclerotium in *C tuberosa* and the lack of it in *C cirrata* Kauffman mentions that some authors (Schroeter, for example) say that *C cirrata* may have a yellowish sclerotium, and that others (Fries, Gillet, *et al*) consider that it has none Kauffman states that he has never seen *C cirrata* with a sclerotium

During 1932 a number of collections were made which fitted well the general description of these species Some had sclerotia, others did not It was observed, moreover, that the sclerotia were of two distinct types One was dark reddish brown and shaped somewhat like an apple seed, and the other was an irregular, nodular body, always of a yellow color The form without sclerotia was striking on account of its habit of growth in dense clusters, clearly growing on a mass of decaying fungous material Under the pines in Saginaw Forest, Ann Arbor, Michigan, in the fall of 1932, it was common to find these dense patches with 30 to 50 or even 100 pilei in them (Pl I, Fig 1) When one collected these fungi, they came

* Papers of the Department of Botany and the Herbarium of the University of Michigan, No 411

up as a whole very easily, and it was seen that they were growing on the remains of old Boleti, apparently *Boletus luteus*, which was common there

The question arose whether one or several species exist The form with the dark reddish brown sclerotia (Pl I, Fig 3) is apparently the same as that which Kauffman regarded as *C tuberosa* The form without sclerotia (Pl I, Fig 1), growing on Boletus, is similar to the plant which Kauffman interpreted as *C cirrata* He states that it grows on decaying vegetable matter in the woods, but does not mention the densely gregarious habit which is so characteristic in our collections The identity of the form with yellow sclerotia (Pl I, Fig 2) was uncertain

A review of the literature resulted in finding that these three forms have been variously interpreted Cooke (3) illustrates *C cirrata* with yellow tuberous sclerotia Schroeter (6), as mentioned above, said that he found *C cirrata* with yellowish sclerotia Bresadola (2) calls the same fungus *C cirrata* Schum var *Cookei* Bres, and recognizes the form without any sclerotia as *C cirrata*, in agreement with the original description of this species

Jaap (4) states that *C tuberosa* occurs only among fallen needles and in moss on remains of fungi of the previous year, and that he found *C cirrata* only on decayed Hypholoma He describes a plant as *C tuberosa* var *etuberosa*, which, so far as the writer can determine, is identical with *C cirrata* Jaap related it to *C tuberosa* because it grows upon Russula and Lactarius, upon which *C tuberosa* is commonly found He emphasizes the point, however, that var *etuberosa* occurs on fungi of the current year, whereas *C tuberosa*, he believes, occurs only on fungi of the previous year

Bresadola (1) figures under the name *Marasmius sclerotipes* Bres a fungus which closely resembles *C tuberosa*, having the dark reddish brown, apple-seed-shaped sclerotium He thinks this is the *C cirrata* of recent authors, not of Fries, but it is not at all clear how he could have arrived at such a conclusion So far as can be determined, *M sclerotipes* Bres differs from *C tuberosa* Fr only in that it grows on leaves instead of on old agarics

It would seem that Bresadola's treatment is the most preferable at the present time The form with the dark reddish brown apple seed-like sclerotia represents the true *C tuberosa* Fr, originally described as *Agaricus tuberosus* by Bulliard and later placed in the

genus Collybia by Fries The form without sclerotia is *C cirrata* Fr, originally described as *Agaricus cirratus* by Schumacher and later transferred to Collybia by Fries The form with the yellowish nodular sclerotia may be regarded, at least for the present, as *C cirrata* Fr var *Cookei* Bres The writer believes that *M sclerotipes* Bres should be considered a synonym of *C tuberosa* Fr

This is the first time that *C cirrata* Fr var *Cookei* Bres has been reported for Michigan The plant has been collected on numerous occasions, it was found in Ann Arbor as early as 1905 These earlier collections were identified as *C tuberosa* or *M sclerotipes*

Collections from the following localities in Michigan have been studied

1 *Collybia tuberosa* Fr
Rock River, Sept 11, 1927, C H Kauffman, No 2598, Rock River, on decayed agaric in swamp, Aug 20, 1932, E B and E E Mains, No 32 184, Oscoda, on decayed agaric material and also on pine needles where agaric material was not evident, Oct 14, 1932, J E Davidson, No C6

2 *Collybia cirrata* Fr
Cedar Lake, west of Chelsea, "on very rotten wood," Oct 12, 1904, C H Kauffman, Saginaw Forest, Ann Arbor, on remains of old Boletus, Oct 1, 1932, J E Davidson, No C3, later collections of the same species from the same place, Nos C4, C9, C10, C11, C12, and C13

3 *Collybia cirrata* Fr var *Cookei* Bres
Ann Arbor, on decayed agaric, Oct 18, 1905, C H Kauffman, Ann Arbor, on soil, Oct 6, 1932, A H Smith (J E Davidson, No C5), Whitmore Lake, Oct 4, 1907, C H Kauffman, Lakeland, on soil, Oct 15, 1932, A H Smith (J E Davidson, No C7), Lakeland, some on agaric material, Oct 15, 1932, E B Mains (J E Davidson, No C8), Duck Lake, north of Pinckney, on humus in woods, Sept 24, 1932, J E Davidson, No C1

These three forms have been grown in culture on several different media and under various light and temperature conditions It has been found that the production of sclerotia and the type of sclerotium formed are very constant and reliable characteristics The writer believes, therefore, that the three forms should be regarded as distinct

The question arises whether they are three varieties of one species,

or two species with a variety of one, or three distinct species It is problematic whether the plant with yellow sclerotia should be regarded as more closely related to *C cirrata*, a plant without sclerotia, than to *C tuberosa*, the plant with the reddish brown sclerotia So far as the pilei are concerned, there is a closer resemblance between *C cirrata* and *C tuberosa* than there is between *C cirrata* and its variety *Cookei*, since the pilei of the first two are ultimately depressed, and those of the form last mentioned are convex or plane as a general rule At the present time the writer is of the opinion that they may be three distinct species It is hoped that cultural studies now in progress may throw some light on this question

The writer wishes to express her gratitude to Dr E B Mains for his many helpful suggestions throughout the course of this study

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EXPLANATION OF PLATE I

FIG 1 *Collybia cirrata* Fr Collected in Saginaw Forest, Ann Arbor, Michigan, on remains of *Boletus luteus*, October 1, 1932, E B Mains, No 32–857

FIG 2 *Collybia cirrata* Fr var *Cookei* Bres Collected in Ann Arbor, Michigan, October 4, 1932 A H Smith

FIG 3 *Collybia tuberosa* Fr Collected at Mud Lake, Whitmore Lake, Michigan, October 25, 1931 E B Mains, No 31–784

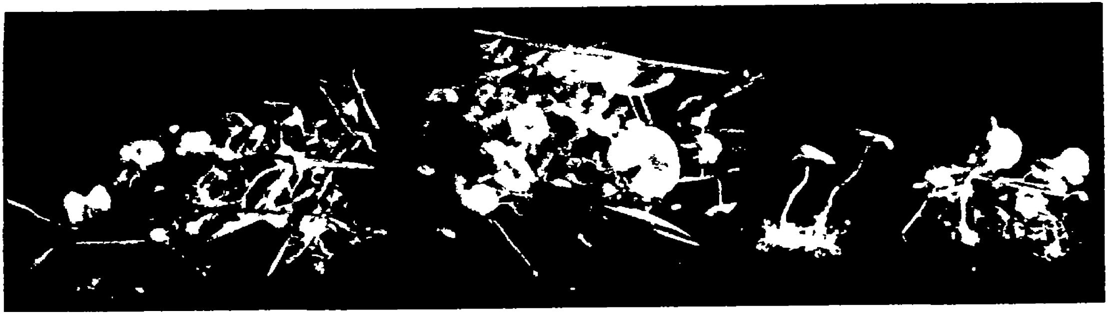

FIG. 2. *Collybia cirrhata* Fr. var. *Cookei* Bres.

FIG. 3. *Collybia tuberosa* Fr.

TWO NEW PALEOBOTANICAL RECORDS FOR THE ANTRIM SHALE OF MICHIGAN *

INEZ MARGARET CLARK

DURING the summer of 1932 two new fossil plants were discovered by the author in the Antrim shale of Michigan. The first was a piece of calcified wood from a roadside exposure on the U. S. highway four miles north of Ossineke in the NW. quarter of Section 22, Alpena Township, Alpena County, Michigan. The other was a lepidodendroid impression from the Paxton quarry, nine miles west of Alpena on the south side of U. S. highway 23 in the NE. quarter of Section 30, T. 31 N., R. 5 E.

The age of this shale, which outcrops in Alpena, Antrim, and Charlevoix counties, has not been definitely fixed. However, Ulrich (9) places its basal member in the upper Devonian, and the upper part, in which most of the plant remains are found, in the Mississippian.

Although plant remains in abundance have previously been discovered in this formation, they have been of only one form — *Calamites inornatus* Dawson. This species was first described and named by Dawson (3). He gave its distribution as Cayuga Lake, New York, Kettle Point, Ontario, and Gaspé, Quebec. Arnold (2) studied it from the Antrim shale exposed in the Paxton quarry. In an examination of fragments of silicified wood obtained by Professor H. H. Bartlett by maceration of the carbonized impressions from this region, he found "the *Callixylon* type of pitting and rays of the *C. Newberryi* type." In view of these discoveries, he states that "these calamite-like structures are the impressions of the smaller branches of *Callixylon* . . . ." The recent discovery of two distinctly new plants from this formation, which has, previous to this time, been notably lacking in the diversity of its fossil flora, emphasizes the incompleteness of our knowledge of the flora of this period.

* Papers from the Department of Botany of the University of Michigan No. 408.

CALLIXYLON SP (*cf* C *erianum* Arnold)

(Plate II)

The specimen of calcified secondary wood is somewhat compressed in places, but on the whole is comparatively well preserved It is referred to Callixylon, a widely distributed genus which was founded by Zalessky (10) The diagnostic character, which is shown in this specimen (Mus Pal, Univ Mich, No 14957) is the grouping of the pits on the radial walls of the tracheids It exhibits several interesting variations from the species described by Arnold (2) from the Antrim formation

Transverse — Tracheids 30–37 × 37–42 microns, quite variable in size and shape, walls rather thick, rays abundant and irregular in width and length

Radial — Bordered pits 2 18, averaging 8–9 in a group, in 2 or 3 vertical rows Pit orifices diagonal, the two opposing ones of each pit arranged in the form of a cross Ray tracheids numerous, in uninterrupted rows, about the same length as the ray cells but one third to two fifths as high Height of ray from 2 to 27 cells, with an average of 6

Tangential Rays numerous, varying in height from 1 to 14 cells, with an average of 5, mostly uniseriate, with occasional biseriation resulting in a widening of the ray

This specimen is related to *Callixylon erianum*, which was founded by Arnold (1) on material from the Upper Devonian of New York State A comparison of the radial sections of the type specimen of *C erianum* with those of the new wood has shown a striking similarity between these forms In his discussion of the former Arnold (1) says "The appearance of the ray tracheids is striking In radial section they are arranged in uninterrupted rows as far as they can be followed, and their tendency to alternate with the ray cells, as well as their uniformly lesser height, are characters peculiar to this form" This description is applicable to the specimen in question In fact, the radial sections of the two are so similar that it would be difficult to distinguish between them (Pl II, Fig 1) Another similarity between *C erianum* and this new form, which is shown in the radial section, is the grouping of the bordered pits *C erianum* has an average of 6–8 per group, the Ossineke specimen, 8–9 per group

Although the radial sections are essentially similar, a study of the transverse sections of the two forms brings forth some differences Whereas *C erianum* is very regular with respect to the size and arrangement of the tracheids and rays, this specimen is quite irregular in both of these characteristics (Pl II, Fig 3)

In the tangential section further differences are encountered First of all, the height of the rays in *C erianum* is much greater, ranging from 2 to 97 cells, the latter number being extremely rare The Michigan form has a range of from 1 to 14 cells, with an average of 5 Both have predominately uniseriate rays, with only an occasional partly biseriate ray Concerning this feature in *C erianum* Arnold (1) says "occasional ray tracheids divided by vertical wall, so that partial biseriation results, but without widening of ray" In the Ossineke specimen there is a definite widening of the ray by biseriation (Pl II, Fig 2)

At present it is difficult to determine whether this new wood from Ossineke, Michigan, should be considered a variation of *C erianum* Arnold or a new species Though there are minor differences, its points of similarity are so striking that one might consider it merely a variation from the type Its status as a new species can be confirmed only by the discovery of more and better preserved wood of this same type

Bothrodendron antrimense, sp nov

(Plate III)

Stem at least 8 cm broad, surface ornamented with spirally arranged, subspatulate to subrhomboidal foliar scars, which are without foliar cushions or visible foliar, parichnos, and ligular markings, leaf scars varying from 5 mm long by 6 mm wide to 3 mm long by 3 mm wide, surface of cortex between leaf scars smooth or with fine longitudinal striations, leaves at least 1 mm wide, bent sharply downward, scattered along stem Type No 14784, Mus Pal, Univ Mich, collected by Inez M Clark at Paxton quarry, nine miles west of Alpena, Michigan, in the Antrim shale

This specimen is a positive impression of a stem, 26 cm long, which is covered in part by a thin layer of coal It tapers gradually, indicating that it had a conical form The foliar scars vary in size and shape (Pl III) in the different parts of the stem, attaining their

greatest dimensions at the tip This condition is probably due to seasonal variation in growth, but possibly to decortication and compression These prints are either flush with the surface or slightly depressed, giving no indication of foliar cushions Although they are without the usual foliar scars of Bothrodendron, it is quite possible that this is the result of decortication rather than an actual lack of these features The scars are never contiguous, although they are much closer together in the upper part of the stem

Along the edge of the specimen are some carbonized remains of leaves In one place, near the base, it is possible to follow these structures into the main stem They appear like continuations of the longitudinal striations which in other parts of the stem seem to originate in the foliar prints The only conclusion that may be drawn in regard to the character of the leaves is that they must have been fairly close together and present on a considerable portion of the stem

This specimen has been assigned to the genus Bothrodendron because it possesses spirally arranged foliar scars, which are without foliar cushions The latter characteristic separates this genus from Lepidodendron (Scott, 7) *B antrimense* does not exhibit foliar, parichnos, and ligular markings, perhaps because of poor preservation rather than an actual lack of the characteristics in question

None of the other genera which various authors have formed for specimens of this same period bears close relationship to *B antrimense* One group, including Cyclostigma, Cyclodendron, and Haplostigma, differs from Bothrodendron in the absence of well-defined markings on their foliar scars Cyclostigma, founded by Haughton (4), includes forms differing from Bothrodendron in the absence of a ligular pit *Cyclostigma kiltorkense* Haught , the original species, has been transferred to Bothrodendron by Johnson (5), who describes the plant as having its leaves in apical tufts and as having marked fluting or ribbing on the stem These characteristics definitely dismiss the possibility of relationship to *B antrimense* Cyclodendron, a South African form, described and figured by Kräusel (6), has rounded foliar scars A comparison of the figures given by Kräusel (6) with *B antrimense* illustrates clearly the difference in shape and arrangement of the foliar scars in the two forms Haplostigma, a genus created by Seward (8) to include forms with smooth, spirally arranged scars and spinous leaves, has a much closer relationship to

the Psilophyteae than to the Lepidodendron-Bothrodendron group, to which *B antrimense* is evidently related

Two other primitive types, Archeosigillaria and Protolepidodendron, possess characteristics which exclude this new fossil Kidston included in Archeosigillaria forms with definite leaf cushions and contiguous foliar scars The species assigned to Protolepidodendron in the past have varied considerably, but, generally speaking, they possess leaf cushions and at least occasionally forked leaves

SUMMARY

Two fossil plants, *Callixylon erianum* Arnold (?) and *Bothrodendron antrimense*, sp nov, have recently been discovered in the Antrim shale of Michigan This formation has previously yielded mostly one species — *Calamites inornatus* Dawson, which, as Arnold (2) has shown, is really based upon impressions of smaller branches of Callixylon of the *C Newberryi* type The new species of Bothrodendron, particularly, has suggested the possibility of further discoveries in this formation

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PLATE II

FIG. 1. Radial section

FIG. 2. Tangential section

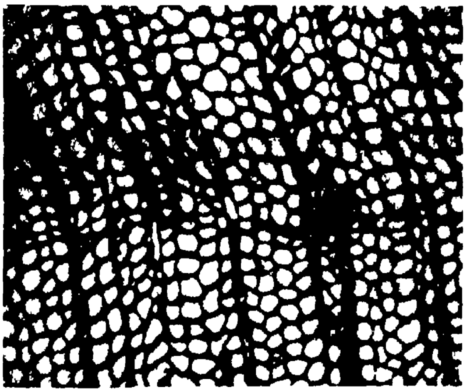


FIG. 3. Transverse section

Callixylon sp. (cf. *C. erianum* Arnold). Antrim shale, Ossineke, Alpena County, Michigan

PLATE III

hredendron antrimense sp. nov. Type specimen No. 14784 Mus. Pal. Univ. Mich. Antrim shale, Paxton quarry, Alpena County, Michigan

THE EFFECT OF A DECREASE IN THE AMOUNT OF TRANSPIRATION ON THE GROWTH OF CERTAIN PLANTS *

FELIX G GUSTAFSON

IN THE summer of 1867 Schloesing (4) conducted an experiment on the effect of reduction in transpiration on plant growth He grew one tobacco plant under a large bell jar for a month and three comparable plants in the open for six weeks The plant under the bell jar transpired only 34 per cent as much as the plants in the open On analysis it was found that this plant had only 13 per cent of ash, the ones in the open, 21 8 per cent, calculated on the basis of dry weight This experiment, dealing with only one plant under a bell jar, has been widely cited as proof that transpiration is necessary to insure that a plant receive the needed amount of minerals The implication is that, if there is a rapid transpiration stream in a plant, more minerals will be absorbed than if this stream moves slowly

If, for the time being, it is admitted that more minerals enter the plant when transpiration is high, there is still no proof that the plant needs all these minerals It may be that the plant would grow as well with much less mineral matter Therefore experiments ought to be conducted to study the effect of a reduction in transpiration on growth

For a number of years there were considerable discussion and speculation in Europe about the effect of transpiration on mineral absorptions and growth Many experiments were conducted, though most of them were very limited in extent and poorly controlled One of the best is that of Wollny (7), who experimented with *Hordeum distichum, Linum usitatissimum, Solanum tuberosum,* and *Ulex europaeus* These plants were grown in three small glass houses, with a volume of 2 4 m^3, placed in the field For the growing season the average relative humidity in these houses was 40 77,

* Paper from the Department of Botany of the University of Michigan, No 399

58.46, and 87.97 per cent. No mention is made of the number of plants used of each species. Wollny found that in the house with the greatest relative humidity the dry weight, the height, and the diameter of the stem and the leaf area were all greater than in the houses with a lower relative humidity. The same thing was true of the absolute amount of ash per plant, when determined.

In 1914 Hasselbring (1) reported an experiment on the relation between the transpiration stream and salt absorption. He reduced transpiration of tobacco plants by shading, which naturally reduced photosynthesis. He found that the more slowly transpiring plants under cheesecloth absorbed more minerals both absolutely and by percentage. The weight of the plants was about the same. Kiesselbach (2), as a part of his extensive experimentation on transpiration as a factor in crop growth, had three small but well-controlled experiments on the effect of humidity on transpiration and production of dry weight in corn. His experiments were conducted in two greenhouse compartments. He found that the dry weight per plant was 6 grams greater in the moist house, where transpiration had been reduced to 62 per cent of that in the dry house. He did not determine the ash content in these experiments. Muenscher (3), however, was also interested in salt absorption as well as in dry weight. In one series of his experimentations he grew barley in small glass cases 140 × 70 × 110 cm. One chamber was kept humid and the other dry. He found practically no difference in dry weight of the two groups of plants and about 1 per cent greater ash content in plants grown in the dry chamber.

In most of these experiments either the controls were poor or the plants were grown under very cramped conditions. The number of individuals was also usually small. Therefore the writer planned an experiment of his own in which there would be a proper control, an abundance of room for the plants to grow in, and a fairly large number of individuals and species. Whole greenhouse compartments were to be used. In the spring of 1930, conditions were favorable for such an experiment.

EXPERIMENTS IN 1930

Experiments were started on June 28, 1930, but during the first ten days the conditions were unsatisfactory. The plants in this first group of experiments were *Zinnia sp.*, *Impatiens Sultani*, *Ly-*

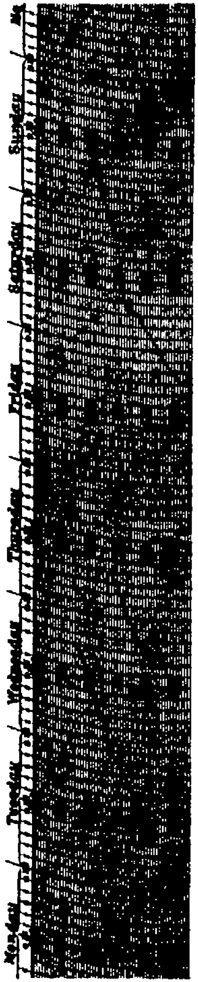
copersicum esculentum, *Zea mays*, *Delphinium sp.*, and *Helianthus annuus*. Fifty plants of each species were potted, and twenty-five of each were placed in each of two similar greenhouse compartments. The compartments measured $11\frac{1}{2} \times 17$ ft., and the roof slanted toward the south. They were located side by side in the same range of houses and may be considered similar in every respect except humidity.

In both houses a strip of burlap 90 cm. wide was tacked to the window frames just above the benches, and the entire north wall, which was the highest wall of the houses, was also covered with burlap. The burlap in the house that was to be maintained moist was watered often enough to keep it saturated during the daytime. The floor and benches also were kept very wet. In the dry house only the soil in the pots was watered. The plants were given an abundance of water to enable them to transpire without wilting. Owing to the care taken in watering the dry house, the humidity was at all times very low. Both houses were well ventilated.

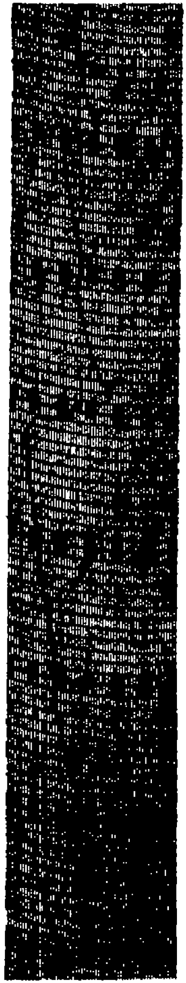
Since there was the same amount of burlap in each house, the plants were equally shaded. As a matter of fact, appreciable shading occurred only while the plants were small. The presence of a humid atmosphere in one house did not interfere with light penetration to any measurable extent. The whole of the earth's atmosphere intercepts only 25 per cent of the visible light (6), and certainly a few feet of a humid atmosphere in a greenhouse would not have any marked effect, so that we may feel assured that in these experiments the light was not an important variable.

The evaporation was determined by atmometers, which were stationed in the two houses on shelves about 120 cm. above the benches. Until the middle of August the atmometers were weighed three times daily, but after that date until the end of the experiment only once daily. Table II gives the average daily loss of water from the atmometers in the two houses. It will be seen that the loss was exactly twice as great in the dry house as in the moist house.

Only one hygrometer was available, and it was placed on the shelf with the atmometer in the moist house. Figure 1 gives the hygrometer readings for the weeks ending July 21 and August 25, 1930. During the first week the temperature was very high, and the humidity ranged between 50 and 80 per cent of saturation, except once, when it went slightly below 50 per cent for three hours. Dur-



July 14 to 21 1930



August 18 to 25, 1930

FIG. 1 Relative humidity in the moist house at two different periods, summer, 1930

ing the week of August 18–25 the relative humidity ranged between 70 and 95 per cent of saturation, except for one day, when it went as low as 64 per cent By means of a sling psychrometer the humidity was also determined three times a day in both houses Table I shows the average relative humidity in the two houses as obtained by the sling psychrometer at 7 A M, 12 noon, and at 6 P M for a period of forty-seven days from July 7 to August 22

TABLE I

AVERAGE RELATIVE HUMIDITY

	7 00 A M	12 00 noon	6 00 P M
Moist house	85 13	73 27	73 59
Dry house	72 98	53 65	51 35

From Figure 1 and Table I it is evident that the humidity in the moist room is fairly high, though it is far from the saturation point Table I further shows that there is considerable difference between the relative humidity of the two houses During the daytime the dry house has a relative humidity 20 per cent less than that of the moist house, but during the night this difference is decreased to about 12 per cent

The tables and figures presented show that the transpiration must be much lower in the moist house than in the dry one The evaporation from the atmometer was only half as great in the moist house as in the dry one, and it is safe to assume that the transpiration was also somewhere near that value

Helianthus annuus (Sunflower)

Two weeks after the commencement of the experiment five plants from each lot of sunflowers were discarded because they were a little older than the rest and had become too large before the humidity was adjusted to be properly influenced by the variable of the experiment

By July 16 the lower leaves on the remaining twenty plants in the dry house began to turn brown and dry up These leaves, as well as others that died later, were saved and dried with the plants Only a few of the lower ones died on the plants in the moist house When the plants were cut on August 9 those in the dry house appeared rather dry, and the leaves had a grayish brown color except those near the tips of the plants The plants in the moist house, on

the other hand, were vigorous and healthy in appearance, with bright green leaves The leaves of the plants in this house were somewhat larger than those in the dry house, the largest measured 17 5 cm in length, as compared with only 15 0 cm for those in the dry house

As will be noticed in Table II, the plants in the moist house had a greater stem diameter, a greater green weight, and a higher percentage of moisture, but were shorter and had a smaller amount of dry material per plant than those grown in the dry house [1]

TABLE II

RESULTS FOR SUMMER OF 1930

	Tomato		Impatiens		Sunflower Lot A		Sunflower Lot B	
	Moist	Dry	Moist	Dry	Moist	Dry	Moist	Dry
No of plants	25	25	24	15	20	20	25	25
Height in cm	130 2	88 98	81 1	61 0	142 1	151 8	162 6	155 0
Stem diameter in cm	1 12	1 02	1 33	1 16	1 295	1 133	1 15	0 925
Fruits per plant	6 64	4 26						
Weight per fruit in grams	228 2	204 8						
Green weight in grams per plant *	340 9	192 1	142 2	88 8	201 3	172 3	153 1	110 15
Dry weight in grams per plant *	32 1	24 34	7 23	5 66	16 23	21 16	12 07	14 71
Percentage of moisture	90 6	87 3	94 9	94 3	91 9	87 7	92 1	86 3
Average daily loss in grams from atmometer for 65 days †	12 47	24 95	12 47	24 95	12 47	24 95	12 47	24 95

* 'Green and dry weights per plant means the weight of leaves and stem, not fruits

† The atmometers were changed back and forth between the two rooms to equalize any difference in the evaporating power of the two porous spheres They were also checked against one another several times during the summer

[1] In all experiments only the tops were used The plants were cut an inch or two above the ground As soon as they were cut they were wrapped in paper until they could be weighed, to insure against loss of water

Because the sunflowers were rather large by the time the experimental conditions had been properly adjusted a second lot was started from seeds on July 8 On July 18 these were put in small pots and on July 30 were transferred to six-inch pots Larger pots would probably have produced larger plants, but the relative results would undoubtedly have remained the same

On September 9 final measurements were made of the plants, and they were then cut down and dried In appearance they were very much like the preceding ones Those in the dry house suffered considerably from the dry atmosphere Several times during the period of experimentation they had to be taken out of the house to be sprayed because of red spiders The red spiders, as well as the dry atmosphere, were probably responsible for the sickly appearance at the end of the experiment The plants in the moist house were vigorous and healthy in appearance All had flower buds, but in general the buds on the plants in the dry house were larger, i e they were further developed The plants in the moist house were taller, had a greater stem diameter, greater green weight, and a higher moisture content, but, again, a lower dry weight than the plants in the dry house

Impatiens Sultani

The Impatiens plants placed in the houses at the beginning of the experiment, June 28, were discarded on July 8, because it was thought that they had reached too great a size before proper moisture conditions were established A new planting was made, these seedlings were potted on July 18, and transferred to five-inch pots on July 30

During the course of the experiment the plants in the dry house suffered, like the sunflowers, from both the dry atmosphere and the red spiders On September 9, when the experiment was terminated, there were only fifteen good plants left in the dry house In the moist house the plants were luxuriant, with no dry leaves, no red spiders, and no spots on the leaves With the exception of five plants they were all in full blossom The blossoms were by far the largest Impatiens blossoms the writer has ever seen None of the plants in the dry house had produced blossoms Table II shows that in every respect the plants grown in the moist atmosphere were superior to those grown in the dry house

Lycopersicum esculentum (Tomato)

Tomato plants were placed in the houses on July 9, at that time they were very small By July 23 practically every plant in both houses had flower buds, and three days later the first flower opened in the moist house, the plants in the dry house followed two days later Artificial pollination produced an abundance of fruits in both houses The plants were all thrifty

On September 10 the plants were cut down At that time only three in the dry house had any branches, whereas nine in the moist house were branched Five in the moist house had one pink fruit each Again the plants in the moist house were in every way superior to those in the dry house, though none in the dry house had suffered any injury either from red spiders or from dying of leaves due to the dry atmosphere

Other plants

The plants of Zinnia, *Zea mays*, and Delphinium were rather large at the time the humidity had finally been properly adjusted, and it was feared that they had grown too long under uncontrolled conditions to give satisfactory results They were therefore discarded after a few weeks

The results of the 1930 experiments may be summed up in a few words All plants grown in moist atmosphere had a higher moisture content, greater green weight, and greater stem diameter than those grown in a drier atmosphere The height was also greater in the moist atmosphere except in the first lot of sunflowers Impatiens and tomatoes had a greater dry weight in the moist house, whereas the greater dry weight was produced by both lots of sunflowers grown in the dry atmosphere Tomato fruits were more numerous and were larger in the moist house

Since only three species of plants were carried through to the end and since the results obtained from them were not uniform, it was decided best to repeat the experiment on a larger scale during the following summer

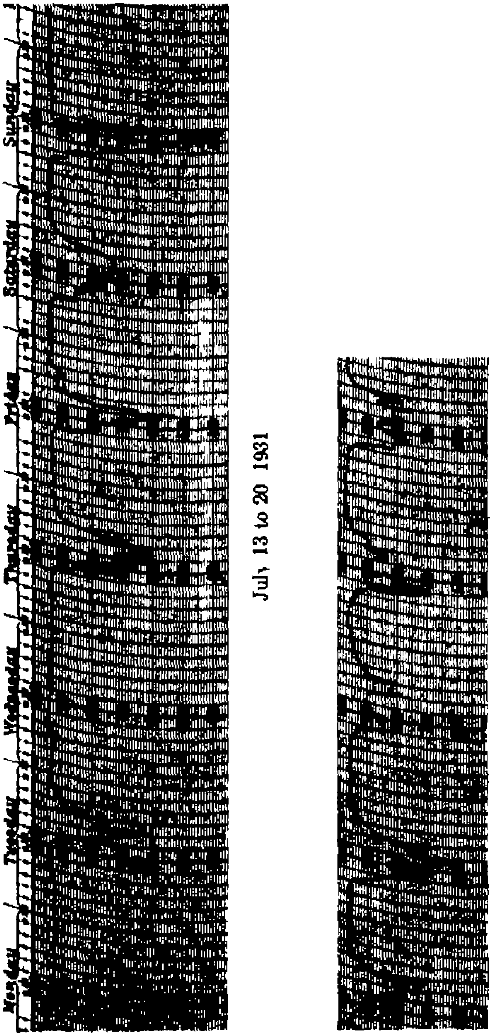
EXPERIMENTS IN 1931

In 1931 four compartments instead of two were available The two of the 1930 season were again used, they will be designated A,

TABLE III

RESULTS FOR SUMMER OF 1931

	Impatiens		Marigold		Zinnia		Sunflower		Tomato	
	Moist	Dry	Moist	Dry	Moist	Dry	Moist	Dry	Moist	Dry
Number of plants	25	21	20	22	25	24	25	25	24	26
Height in cm	96 0	54.2	153 4	100 2	151 6	91 0	161 7	172 9	145.4	136 5
Stem diameter in cm.	1 66	1 63			0 76	0 69	1 30	1 11	0 91	0 87
Green weight per plant in grams	279 0	160 0	124.1	73 8	112 1	65 7	203 1	145 1	318 7	231 9
Dry weight per plant in grams	13 48	8 15	10 65	8 7	12 04	8 47	10 56	12 5	24 39	19 67
Percentage of moisture on basis of green weight	95 0	94.7	91 5	88.3	89 2	87 2	94.8	91 3	92 4	91 7
Percentage of ash	17 28	16.98			8 45	9 03	24 64	19 95	20 56	18 22
Age of one plant days	69	69	64	64	75	75	69	69	79	79
Average temperatures										
Minimum	68 4	64 0	68.4	64.0	68 4	64 0	67 0	68.8	67 0	68 8
Maximum	96 0	102 0	96 0	102 0	96 0	102 0	93 0	96 0	93 0	96 0
Average atmometer loss per day in grams	6 62	19 42	6 62	19 42	6 62	19 42	8 01	17 48	8 01	17 48



July 13 to 20 1931

August 10 to 14 1931

Fig 2 Relative humidity in the moist house at two different periods summer 1931

the dry house, and B, the moist. The other two, C, the dry house, and D, the moist, were a little narrower and were located in another range of houses, but had a similar southern exposure. Burlap was again tacked on the windows for 90 cm. above the benches and on the north walls of the rooms. All rooms were provided with maximum and minimum thermometers and with atmometers. A hygrometer was again used in the moist room where it had been during the preceding summer. Two thermographs were also available; they were placed in rooms A and B on the shelves with the atmometers. As during the preceding season, the atmometers were frequently checked against one another and occasionally changed from one room to the other.

Every day between 8 and 10 o'clock in the morning atmometer and temperature readings were taken, as well as notes on the plants. The relative humidity was much greater and more nearly constant than during the preceding season, as will be seen from Figure 2. As is indicated by Table III, the atmometer loss was lower than it had been during the preceding year, averaging 17.48 grams per day for dry house A, and 8.01 for moist house B. It will be noted that in this year the evaporation in the moist house was 45.8 per cent of that in the dry house, instead of 50 per cent, as during the preceding summer. The lower evaporation in the dry house was no doubt due to a season of greater moisture and the decrease in the moist house to a more efficient method of keeping the air moist. The difference in the evaporation between the two new houses, C and D, was much greater than between houses A and B. The evaporation from the atmometer in the wet house was only 38.8 per cent of that in the dry house. The minimum and maximum temperatures differed very little between houses A and B, but between C and D the difference was somewhat greater, though here it was not greater than 6 degrees Fahrenheit. It does not seem that this difference in temperature would be of great influence, since the dry house had the higher temperature and since this would further increase the difference in the amount of transpiration.

In the 1931 experiments *Zea mays*, *Zinnia* sp., *Lycopersicum esculentum*, *Helianthus annuus*, *Delphinium* sp., *Impatiens Sultani*, and *Tagetes patula* were used. The seeds were planted on June 1; the plants had been transferred to six-inch pots and were ready for the beginning of the experiment on June 17.

Helianthus annuus (Sunflower)

The Helianthus plants were grown in houses A and B, as in the preceding season Those in the dry house suffered a little from red spiders and cyanide fumigation During the last week of growth some of the leaves of several plants were partly eaten by caterpillars This necessarily decreased both the green and dry weights somewhat, though the decrease was probably negligible

On August 8, when the sunflower plants were cut, none of the plants were branched Short adventitious roots had developed in the first and second internodes on all plants in the moist house, but none on those in the dry house Only two flower buds were noted in each house, those in the dry house being the larger The average height was greater in the dry house, where the height was quite uniform, ranging from 153 to 192 cm , in the moist house the height ranged from 118 to 204 cm The average number of leaves was 26 per plant in both houses The leaves in the dry house were slightly larger The diameter of the stem, which was taken 43 cm from the soil, was greater in the moist house plants

In summarizing we find that the plants in the dry house had a greater average height and dry weight, whereas the plants in the moist house showed a larger stem diameter, a greater green weight, and also a larger percentage of moisture and ash The ash was calculated on the basis of dry weight Thus the three lots of sunflowers agree in every respect except height, two lots showed greater height in the dry house, but one lot had taller plants in the moist house The surprising thing is that the ash should be more abundant in the moist house plants, where there had undoubtedly been a lower rate of transpiration This result accords with Hasselbring's

Lycopersicum esculentum (Tomato)

Tomato plants grew very well in both houses, though, as shown by Table III, the plants in the moist house did better These plants had not been injured either by hydrocyanic acid fumigation or by red spiders, but just before they were cut some leaves in the dry house had been partly eaten by caterpillars The damage, however, was unimportant There seemed to be no difference in time of production or in the number of blossoms under dry and humid conditions Only two fruits were produced in the dry house,

there were none in the moist house, no doubt owing to lack of artificial pollination Adventitious roots were numerous halfway up the stem on plants in the moist house, the plants in the dry house had none The roots were all short except on one plant, where they grew into the soil All plants were branched, the average number of branches per plant in the dry house was three, in the moist house, five

The striking contrast in the plants between the two seasons is the lack of fruits in 1931 and the large number of branches in that year, the 1930 plants had many fruits but few or no branches The lack of fruits in 1931 was undoubtedly due to neglect of hand pollination With no fruits to support, it is probable that branches were formed in great numbers on the 1931 plants In 1931, as in 1930, plants grown in moist atmosphere were superior in every way, even having a higher percentage of ash

Zea mays (Corn)

The weight of the wet leaves early resulted in injury to the plants in the moist house and therefore both lots of corn plants were discarded after a few weeks

Impatiens Sultani

Impatiens was grown in houses C and D, where the difference in evaporation and humidity was very large This year also Impatiens suffered from red spiders in the dry house, though not nearly so much as in the preceding summer At the end of the experiment four plants were discarded as being badly affected, but the others were in fairly good condition The plants in the moist house were injured by too heavy fumigation with hydrocyanic acid on July 12, but recovered

The plants were cut down on August 8 At this time nine were in blossom in the moist house and only one in the dry house As shown by Plate IV, Figure 1, the plants in the moist house were much taller and more branched than those in the dry house, and their leaves were also larger and greener Many of those in the moist house had long adventitious roots developed either from the base of the lowermost branches or at the first internode (Pl IV, Fig 2) No plants in the dry house developed roots from the stem Table III shows that plants grown in the moist house were su-

perior to those grown in the dry house This agrees with the 1930 results

Tagetes patula (Marigold)

The marigolds were also grown in houses C and D The plants in the moist room were injured somewhat by hydrocyanic acid on July 12, but recovered after a while, showing no permanent injury, except possibly in the matter of blossoming All were rather slender, those in the moist house were very brittle, breaking off at the least contact

At the time the plants were cut, August 3, the moist-house plants were one and one-half times as tall as those in the dry house, but they averaged only half an internode more In the moist house the branches, the average number of which was nine, were much longer than those in the dry house Only three plants in the dry house had blossoms, none in the moist house blossomed At the time of cutting sixteen plants in the moist house had adventitious roots, extending quite a way up the stem Wherever a stem had been bent down and thus became partly broken, the roots were very numerous just above the bend No dry-house plants produced adventitious roots There was no apparent difference in the size of the leaves in the two houses, but the color was a somewhat darker green in the moist house

Zinnia sp

Like the other plants in house D the zinnias were injured by the heavy fumigation on July 12 The first blossom appeared on a plant in the dry house on July 17, the first one in the moist house opened on July 22 On August 14, when the plants were cut, twenty were in blossom in the dry house and twenty-two in the moist The flower heads in the dry house were globose, with numerous strap flowers, those in the moist house were flatter, and had fewer but larger and much brighter and fresher strap flowers The number of heads was greater in the dry house In the moist house twenty-one plants had adventitious roots, sometimes as high as the ninth internode These roots were short, but very numerous, especially where the stems were tied with raffia to the support or, in one stem, above a twist No dry-house plants had adventitious roots All plants in the moist house had branches, from two to six per plant, and these were very long, some, in fact, were longer than the main stem

With one exception the dry-house plants also had branches, but they were, for the most part, very short The average height of the moist-house plants was 66 per cent greater than that of the dry-house plants (Pl IV, Fig 3) This greater height was partly associated with longer internodes and partly with more numerous internodes, the moist-house plants had two more internodes than the dry-house plants Of the four species of plants in which ash determination was made, Zinnia was the only one in which the dry-house plants had a higher percentage of total ash, and that was only one half of one per cent In every other respect the moist-house plants exceeded the dry-house plants

Delphinium sp

In the moist house the Delphinium plants were so located that when the house was sprinkled the pots always received an excess of water and consequently the plants did not develop very well These were not measured Even though there was no intention of including them in the final result, the blossoming was noted The first blossom opened in the moist house on July 25, the first in the dry house, on July 28 On August 6 all plants were in blossom

The results for 1931 may be summarized by the statement that all plants grown in the moist house had a greater stem diameter, a greater green weight, and a higher percentage of moisture, that all except the sunflower had a greater height and dry weight, that all but Zinnia had a greater percentage of ash than those grown in the dry house and that the moist-house plants as a rule produced adventitious roots, whereas those in the dry house had none

DISCUSSION

Before discussing the data presented in the preceding pages it may be well to consider what constitutes a proper criterion of growth To the writer it seems that the height of a plant is not such a criterion, since tall and spindling plants may be formed without much or any addition to their organic material This is especially true in subdued light Nor can green weight, which may be mostly due to absorption of water, be considered a measure of growth The amount of ash or minerals in a plant can no more satisfactorily be used to measure the amount of growth the plant has made It would seem that the only proper criterion of growth is the dry weight

of the plant, since this is the resultant of the anabolic and catabolic processes that were carried on while the plant was living

In these experiments the transpiration of none of the plants located in either the moist or the dry houses has been determined, and the question may well be raised whether the transpiration was any higher in the dry house than in the moist house, even though the humidity and the evaporation from the atmometer were much greater than in the moist house The plants in the dry house may have been modified to reduce transpiration, by a reduction in the number of stomata, by the production of a thick cuticle, or in some other way The number of stomata in the lower epidermis of older leaves from the two environments were counted in the sunflower, tomato, and Impatiens There was no appreciable difference In another connection Miss Elizabeth Halfert also counted the stomata on some of these plants, her counts agree with those of the writer

The transpiration must, of course, have been reduced greatly According to Shreve (5), transpiration takes place even when the relative humidity is as high as 98 per cent, in Schloesing's experiments the plant under the bell jar transpired 34 per cent as much as the plants in the open In the present experiments, however, the transpiration may possibly have been reduced 50 to 60 per cent Under these conditions the only plant which showed a greater dry weight under high transpiration than under the reduced transpiration was the sunflower, which consistently did so It seems reasonable, therefore, to conclude that it is not true that a high rate of transpiration is conducive to plant growth, because the rapid movement of water in the plant aids the distribution of the necessary minerals This will be especially obvious when it is pointed out that, of the four species of plants in which the percentage of total ash was determined, only one had a slightly lower ash content in the plants grown in the moist house, and this was not the sunflower which showed the lesser growth in the moist house, but Zinnia, which had a dry weight 43 per cent greater in the moist house than in the dry house The mineral content could not have been a factor of growth here

The humid atmosphere surrounding the plants was more favorable to elongation of the stem than was the dry atmosphere, except in the case of the sunflower In all other plants the height, the number of branches, and their length, as well as the diameter of the stem,

were usually much greater in the humid atmosphere Adventitious roots were also produced in great profusion in the humid atmosphere, a thing which never happened in the dry atmosphere It is certain, however, that there was no lack of water in the plants of the dry houses, since they were never permitted to wilt and since the percentage of water in the plants did not vary widely

As regards flowering, not much can be said, except that Impatiens certainly blossomed with greater profusion in the humid atmosphere than in the dry Zinnia produced longer and brighter strap flowers in the moist atmosphere, but not so many as in the dry The sunflowers may possibly have had slightly further developed flowers in the dry atmosphere

In general, it may be stated that the sunflower grew somewhat better in a dry atmosphere, but that all the other species grew better in a humid atmosphere

SUMMARY

1 *Impatiens Sultani, Lycopersicum esculentum, Zinnia sp*, and *Tagetes patula* were taller, greater in stem diameter, had a greater green and dry weight and more and longer branches in a humid atmosphere than in a dry atmosphere

2 In two out of three lots of *Helianthus annuus* the plants were taller in a dry atmosphere than in a humid one

3 All *Helianthus annuus* plants had a greater stem diameter and a greater green weight in a humid atmosphere, but a greater dry weight in a dry atmosphere

4 Zinnia plants had a slightly higher percentage of ash in a dry atmosphere, Impatiens, Lycopersicum, and Helianthus had a higher percentage of ash in the humid atmosphere

5 All species produced numerous adventitious roots in the humid atmosphere, but never in the dry atmosphere

6 Impatiens had a great profusion of blossoms in a humid atmosphere, only a few blossoms were produced in the dry one

The writer takes this opportunity to express his indebtedness to Mr L A Griffin for his care of the experiments for the greater part of the summer of 1930, to Miss Elizabeth Halfert, for her aid in the 1931 experiment, and to Mr H F Hammond, for the three photographs

UNIVERSITY OF MICHIGAN

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Fig. 1

Fig. 2

Fig. 3

Fig. 1. *Impatiens Sultani*. The two plants at the ends were grown in the moist house, the one in the middle in the dry house. Note the adventitious roots on the plant on the left.

Fig. 2. Adventitious roots on an *Impatiens Sultani* plant grown in the moist house.

Fig. 3. *Zinnia* sp. The plant on the left was grown in the moist house, the one on the right in the dry house. The differences are in the floral heads, the size of the leaves and the length of the internodes.

NEW OEDOGONIA COLLECTED IN CHINA *

CHIN CHIH JAO

FROM 1929 to 1932 the writer has had in hand numerous fresh-water algae collected in different localities of China by himself and his friends It is now proposed in this initial report to deal with new species and varieties of the genus Oedogonium

The new types, *Oe spiralidens*, *Oe orientale*, *Oe costatosporum*, *Oe excavatum*, *Oe intermedium* Wittrock var *szechwanense*, and *Oe cymatosporum* Wittrock & Nordstedt var *chungkingense* were found on permanently flooded ground of rice farms near Chungking, Szechwan, West China, *Oe crassum* (Hassall) Wittrock var *orbiculare* was collected in a permanent pond, near Wuchang, Hupeh, Central China

Chungking and Wuchang are both in the temperate zone and have a moderate rainfall, the farms or ponds seldom become dry or frozen in winter, especially near Chungking, although the water level is lowered or the ground dried in some parts at the time of rice harvest The permanent rice farms in Szechwan are generally placed between hills or mountains and adjoin one another, at times forming series of terraces several miles long from the higher to lower altitudes Therefore, as a rule the lower farms are flooded from the higher ones, and the water is kept about one foot deep in summer and from one to four feet in winter On these farms the soil, composed of unusually fine particles and containing a large proportion of colloids, is very fertile As a result, the algae on the farms, especially the lower ones, are generally associations of many kinds which have been scattered and mixed during overflowing and irrigation, except certain species of Spirogyra, Zygnema, Cladophora, Vaucheria, Chara, and others, which are comparatively unmixed and of isolated distribution in the most favorable localities

The new Oedogonia found near Chungking are associated with species of Zygnemataceae, blue-green algae, other species of Oedo-

* Papers from the Department of Botany of the University of Michigan, No. 404

gonium,[1] such as *Oe multisporum* Wood, *Oe Richterianum* Lemmermann, *Oe crispum* (Hassall) Wittrock var *uruguayense* Magnus & Wille, and *Bulbochaete varians* Wittrock *Oe crassum* (Hassall) Wittrock var *orbiculare*, which is the largest species among my collections of this genus, occurs rather abundantly in a pond near Wuchang

Oedogonium spiralidens, sp nov

(Tab V Figg 1–3)

Oedogonium dioicum, nannandrium, oogoniis singulis, subglobosis vel oboviformi-globosis, poro mediano apertis oosporis globosis vel subglobosis, maturitate flavidi viridibus, axe transversis, oogonia fere complentibus, membrana duplici episporio subtiliter granulato, costato, costis spiralibus 4 7 manifestissime denticulatis, quandoque anastomosantibus in polis cellulis suffultoriis tumidis, nannandribus paululum curvatis, in suffultoriis sedentibus, antheridiis exterioribus, 1–3-cellularibus cellula basali tumida, breviore quam cellulis vegetativis

Cellulae vegetativae	12 18 μ diam , 50–76 μ long
Oogonia	42–50 μ diam , 40 47 μ long
Oosporia	40–46 μ diam , 36–46 μ long
Cellulae suffultoriae	20 26 μ diam , 62–76 μ long
Nannandris stipes	10 12 μ diam 38–40 μ long
Cellulae antheridii	6–8 μ diam , 8 12 μ long

In provincia Szechwan, Sina, loco dicto Chungking, legit auctoris soror Chun Jao Specimina in collectionibus auctoris et Herbarii Universitatis Michiganensis conservata sub numeris S270 014 (typico), 030, et 031

Dioecious, nannandrous, oogonium solitary, subglobose to obovoid-globose, pore median oospore globose or subglobose, yellowish green at maturity, the polar axis always transverse to the axis of filament, nearly filling the oögonium, spore wall of two layers, the outer layer finely granulate and marked by 4–7 spiral ribs uniting and sometimes anastomosing at the pole, the edge of the ribs irregularly dentate, suffultory cell enlarged, dwarf male slightly curved, on the suffultory cell, antheridia exterior, 1–3, basal cell swollen, shorter than the vegetative cell

[1] Tiffany L H , *The Oedogoniaceae* (Privately printed, Columbus, Ohio, 1930)

Vegetative cells	12 18 μ diam	50 76 μ long
Oögonia	42–50 μ diam	40 47 μ long
Oöspores	40 46 μ diam	36–46 μ long
Suffultory cells	20 26 μ diam	62 76 μ long
Dwarf male stipes	10 12 μ diam	38–40 μ long
Antheridial cells	6 8 μ diam	8–12 μ long

This species is near *Oedogonium illinoisense* Transeau, *Oe exospirale* Tiffany, and *Oe spirale* Hirn It is distinguished from the first in that the sexual cells have smaller dimensions, the suffultory cells are not much swollen, and the vegetative cells are shorter It differs from the second in the rather larger diameter of the oöspore, the dwarf male stipe and vegetative cell, and the smaller antheridia It is separated from the third species by its smaller dimensions The Chinese plants differ from all three collectively in having the spiral ribs irregularly toothed and in a markedly granulate outer spore wall

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by Miss Chun Jao, Aug, 1930 Type in the collections of C C Jao and the Herbarium of the University of Michigan, Nos S270 014, 030, and 031

Oedogonium orientale, sp nov

(Tab V Figg 4–7)

Oedogonium dioicum, macrandrium, oogoniis solitariis, oblongi-ellipsoideis vel oblongi-oboviformibus, poro superiore apertis, oosporis ellipsoideis, maturitate flavidi-viridibus, longitudinaliter oogonia non complentibus, membrana oosporarum triplici episporio laevi, mesosporio longitudinaliter costato (in sectione optica transversali undulato), costis continuis non anastomosantibus, in medio oosporae circa 16–20, endosporio laevi, plantis masculis paululo gracilioribus quam femineis, antheridiis 1 5-cellulis, sparsis in filamenti parte superiore, spermatibus divisione horizontali binis, cellulis vegetativis inferioribus plantarum mascularum et feminearum vulgo elongatis, cellula basali leviter tumida, cellula terminali raro apice obtusa plerumque setiformi, seta hyalina, frequenter 280 μ longa

Cell veg planta fem	*10–20 μ diam*	*64 142 μ long*
Cell veg planta masc	10–16 μ diam	70–148 μ long
Oogonia	33–50 μ diam,	75–90 μ long
Oosporia	30–47 μ diam	52 65 μ long
Cell antheridii	11–14 μ diam	8–17 μ long

In agris permanenter inundatis prope Chungking in provincia Szechwan, Sina Occidentali, legit auctor Specimina in collectionibus auctoris et Herb Univ Mich conservata sub numeris S316 04, 05, 08, et 09

Dioecious, macrandrous, oögonium solitary, oblong-ellipsoid or oblong-obovoid, pore superior, oöspore ellipsoid, yellowish green at maturity, not filling the oögonium longitudinally, spore wall of three layers outer layer smooth, middle layer with 16–20 continuous, entire, longitudinal ribs, inner layer smooth, male filament rather more slender than the female, antheridia 1–5, scattered, often in the upper part of the filament, sperms 2, formed by horizontal division, lower cells of both male and female filaments generally elongate, basal cell slightly swollen, elongate, terminal cell extended into a long hyaline seta up to 280 μ in length, rarely apically obtuse

Vegetative cells female plant	10–20 μ diam , 64–142 μ long
Vegetative cells, male plant	10–16 μ diam 70–148 μ long
Oögonia	33–50 μ diam , 75–90 μ long
Oöspores	30–47 μ diam , 52–65 μ long
Antheridial cells	11–14 μ diam , 8–17 μ long

This species is near *Oedogonium leiopleurum* Nordstedt & Hirn and *Oe Boscii* (Le Clerc) Wittrock, its f *dispar* Hirn, var *notabile* Lemmermann, and var *occidentale* Hirn It differs, however, from the first in having a longer oögonium, with the oöspore not filling it, smooth outer spore wall, fewer longitudinal ribs, a lower number of seriate antheridia, and the terminal cell generally in the form of a long hyaline seta, from the second in having a smooth outer spore wall and 18–20 longitudinal ribs on the middle spore wall only, the sperm division horizontal, and the terminal cell extending into a long hyaline seta From the form and varieties the Chinese plants differ chiefly in relative size, number of ribs, shape of oögonium and of terminal cell

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by the writer, Feb , 1932 Type in the collections of C C Jao and Herb Univ Mich , Nos S316 04, 05, 08, and 09

Oedogonium crassum (Hassall) Wittrock var orbiculare, var nov

(Tab VII, Figg 22-23)

Oedogonium dioicum, macrandrium, oogoniis solitariis, globosis vel oboviformibus, raro pyriformibus, poro superiore apertis, oosporis globosis vel subglobosis vel oboviformibus, oogonia plus minusve complentibus, membrana oosporarum laevi et crassa plantis masculis paululo gracilioribus quam femineis vel eas aequantibus, antheridiis 3-11-cellularibus, spermatibus divisione verticali binis, cellulis vegetativis cylindricis vel leviter tumidis, cellula basali breviter obtusa

Varietas similis est *Oe crasso* (Hassall) Wittrock, f *amplo* Hirn, var *longo* Transeau et var *subtumido* Hirn, sed differt magnitudine minore et praecipue longitudine cellularum sporiferarum

Cell veg , planta fem	29 50 μ diam , 55–191 μ long
Cell veg , planta masc	24–45 μ diam 55–155 μ long
Oogonia	64–83 μ diam 70-100 μ long
Oosporia	61–76 μ diam , 61 83 μ long
Cell antheridii	29–34 μ diam 8 16 μ long

In stagno parvo prope Wuchang, in provincia Hupeh, Sina Centrali, legit amicus meus C Hwang Specimina in collectionibus auctoris et Herb Univ Mich conservata sub numeris W1 02, 04, et 05

Dioecious, macrandrous, oögonium solitary, globose to obovoid, or obovoid-ellipsoid, rarely pyriform, pore superior, oospore globose, subglobose, or obovoid, filling or not filling the oögonium, spore wall smooth and thick, male filament a little more slender than the female or equal in dimensions, antheridia 3-11-seriate, sperms paired, division vertical, vegetative cell cylindrical or slightly swollen, terminal cell of the filament short, obtuse

Vegetative cells female plant	29–50 μ diam 55-191 μ long
Vegetative cells, male plant	24-45 μ diam , 55–155 μ long
Oögonia	64 83 μ diam , 70–100 μ long
Oöspores	61–76 μ diam , 61–83 μ long
Antheridial cells	29–34 μ diam 8–16 μ long

This variety resembles *Oedogonium crassum* (Hassall) Wittrock, its f *amplum* (Magnus & Will) Hirn, var *longum* Transeau, and var *subtumidum* Hirn It is characterized by its smaller size, particularly the length of fruiting cells

Collected in a permanent pond, Wuchang, Hupeh, Central China,

by Mr C Hwang, Sept, 1931 Type in the collections of C C Jao and Herb Univ Mich, Nos W1 02, 04, and 05

Oedogonium costatosporum, sp nov

(Tab VI, Figg 8-10)

Oedogonium dioicum, macrandrium, oogonus solitarns, ellipsoideis vel subellipsoideis, operculo superiore apertis, oosporis oogoniis conformantibus et lumen plane complentibus vel fere complentibus, membrana triplici, episporio laevi, mesosporio longitudinaliter costato, costis continuis vel raro anastomosantibus, in medio oosporae circa 20 28, antheridiis saepe 11-cellularibus, spermatibus divisione horizontali binis, cellula terminali obtusa, cellulis vegetativis inferioribus gracilioribus quam superioribus

Cell veg planta fem	12 20 μ diam	40 110 μ long
Cell veg planta masc	12-20 μ diam	72-105 μ long
Oogonia	38-45 μ diam,	58-68 μ long
Oosporia	36 42 μ diam	50-63 μ long
Cell antheridii	14 17 μ diam	11 19 μ long

In agris permanenter inundatis prope Chungking in provincia Szechwan, Sina Occidentali, legit auctoris soror Chun Jao Specimina in collectionibus auctoris et Herb Univ Mich conservata sub numeris S270 010, 019, et 020

Dioecious, macrandrous, oogonium solitary, ellipsoid to subellipsoid, operculate, division superior, oospore of the same form as the oogonium, filling or nearly filling the oögonium, spore wall of three layers outer layer smooth, middle layer longitudinally ribbed, ribs 20-28, entire, sometimes anastomosing, antheridia often 11-seriate, sperms 2, formed by horizontal division, terminal cell apically obtuse, lower cells of the filament usually more slender than the upper ones

Vegetative cells female plant	12 20 μ diam,	40-110 μ long
Vegetative cells, male plant	12-20 μ diam	72-105 μ long
Oögonia	38-45 μ diam	58-68 μ long
Oöspores	36-42 μ diam	50-63 μ long
Antheridial cells	14-17 μ diam,	11-19 μ long

This species is characterized among the dioecious species with ellipsoid and operculate oögonia and longitudinally ribbed oöspores by its smaller dimensions, especially of the fruiting cells, and by the

number of ribs The most similar species is *Oe australianum* Hirn It differs, however, in having smaller oögonia and oöspores, a larger number of ribs, and antheridia of greater dimensions in much longer series It is also similar to *Oe tumidulum*, but is different from it in having smaller dimensions, fewer longitudinal ribs, and a lower number of seriate antheridia

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by Miss Chun Jao, Aug, 1930 Type in the collections of C C Jao and Herb Univ Mich, Nos S270 010, 019, and 020

Oedogonium *intermedium* Wittrock var **szechwanense,** var nov

(Tab VI Figg 15-17)

Oedogonium monoicum oogoniis singulis, globosis vel depresso-globosis, poro superiore apertis, oosporis forma oogoniis similibus et ea non complentibus, membrana oosporarum laevi et spissa, antheridiis 1-6-cellularibus, subepigynis vel subhypogynis vel sparsis, cellulis vegetativis gracilibus, cellula basali tumida, non elongata, cellula terminali apiculata

Cellulae vegetativae	10 15 μ diam 35 95 μ long
Oogonia	40 50 μ diam 40–43 μ long
Oosporia	35–40 μ diam, 35–40 μ long
Cellulae antheridii	10 14 μ diam 4 9 μ long

In agris permanenter inundatis prope Chungking in provincia Szechwan, Sina Occidentali, legit auctoris soror Chun Jao Specimina conservata sub numeris S270 08A, 018, et 029

Monoecious, oögonium solitary, globose to depressed-globose, with superior pore, oospore of same form as the oögonium and not filling it, spore wall smooth and thick, antheridia 1-6, subepigynous, subhypogynous, or scattered, vegetative cell slender, basal cell swollen, not elongate, terminal cell apiculate

Vegetative cells	10 15 μ diam 35–95 μ long
Oögonia	40 50 μ diam 40–43 μ long
Oöspores	35 40 μ diam, 35–40 μ long
Antheridial cells	10–14 μ diam, 4–9 μ long

This variety bears some resemblance to *Oe intermedium* Wittrock and its var *fennicum* Tiffany, *Oe Hirnii* Gutwinski and its var *africanum* G S West, *Oe globosum* Nordstedt, and *Oe fragile*

Wittrock It differs, however, from all similar species, except *Oe fragile*, in having larger and usually more depressed-globose oögonia and comparatively slender vegetative cells It especially separates from the first and its variety in the smaller dimensions of the antheridial cells, from the second and its variety in having the depressed-globose oöspore not filling the oogonium, basal cell not elongate, and terminal cell apiculate in form It differs from *Oe fragile* in having depressed-globose oögonia and the rather smaller oöspores not filling them, comparatively short vegetative cells and shorter to 6-seriate antheridial cells

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by Miss Chun Jao, Aug , 1930 Type in the collections of C C Jao and Herb Univ Mich , Nos S270 08A, 018, and 029

Oedogonium excavatum, sp nov

(Tab VII Figg 18–21)

Oedogonium monoicum, oogoniis singulis, globosis vel oboviformibus vel subglobosis, poro superiore apertis, oosporis globosis vel subelliptico-globosis, oogonia complentibus vel fere complentibus, membrana oosporarum triplici, episporio laevi, mesosporio scrobiculato, antheridiis 2–5-cellularibus, subepigynis vel hypogynis vel subhypogynis vel sparsis, antherozoidiis divisione horizontali binis, cellula basali elongata, cellula terminali obtusa

Cellulae vegetativae	18–25 μ diam 30–135 μ long
Oogonia	45–60 μ diam , 50–65 μ long
Oosporia	42 55 μ diam , 45 60 μ long
Cellulae antheridii	18 22 μ diam , 7 12 μ long

In agris permanenter inundatis prope Chungking in provincia Szechwan, Sina Occidentali, legit auctoris soror Chun Jao Specimina in collectionibus auctoris et Herb Univ Mich conservata sub numeris S270 02, 011, et 013

Monoecious, oögonium solitary, globose to obovoid or subellipsoid, with superior pore, oöspore globose to subellipsoid-globose, filling or nearly filling the oögonium, spore wall in three layers outer smooth, middle scrobiculate, antheridia 2–5, subepigynous, subhypogynous, or scattered, sperms 2, division horizontal, basal cell elongate, terminal cell of the filament obtuse

Vegetative cells	18–25 μ diam	30–135 μ long
Oögonia	45 60 μ diam	50–65 μ long
Oöspores	42–55 μ diam	45 60 μ long
Antheridial cells	18 22 μ diam	7–12 μ long

This species is near *Oedogonium foveolatum* Wittrock It differs, however, in being of rather large size, especially the oogonium and oöspore, and in having the middle spore wall scrobiculate

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by Miss Chun Jao, Aug, 1930 Type in the collections of C C Jao and Herb Univ Mich, Nos S270 02, 011, and 013

Oedogonium cymatosporum Wittrock & Nordstedt var **chungkingense,** var nov

(Tab VI, Figg 11–14)

Oedogonium monoicum, oogoniis singulis, rarius binis vel *ternis*, subdepresso-globosis vel depresso-globosis, poro mediano, rimiformi, oösporis depresso-globosis, maturitate fuligineis, oogonia plane complentibus vel fere complentibus, membrana triplici episporio et endosporio laevi, mesosporio scrobiculato, antheridiis 1–6-cellularibus, subepigynis vel rarius sparsis, antherozoidiis singulis, cellula basali elongata, sursum leviter tumida, prope hapteron valde angustata

Cellulae vegetativae	4-8 μ diam	15–30 μ long
Oögonia	20 24 μ diam	19–23 μ long
Oösporia	19–23 μ diam	16–19 μ long
Cellulae antheridii	4–6 μ diam	2–8 μ long

In agris permanenter inundatis prope Chungking in provincia Szechwan, Sina Occidentali, legit auctor Specimina in collectionibus auctoris et Herb Univ Mich conservata sub numeris S316 02, 03, 04, et 05

Monoecious, oogonium solitary, rarely two to three in groups, subdepressed-globose to depressed-globose, pore median, rimiform, oöspore depressed-globose, smoky brown at maturity, filling or nearly filling the oögonium, spore wall of three layers outer and inner smooth, middle layer scrobiculate, antheridia 1–6, subepigynous, rarely scattered, sperm single, basal cell elongate, slightly swollen above, greatly contracted toward the expanded hapteron

Vegetative cells	4–8 μ diam , 15–30 μ long
Oögonia	20–24 μ diam , 19–23 μ long
Oöspores	19–23 μ diam , 16–19 μ long
Antheridial cells	4–6 μ diam , 2–8 μ long

This species is similar to *Oedogonium cymatosporum* Wittrock & Nordstedt and *Oe Magnusii* Wittrock It is distinguished, however, from the first by the smaller size of all cells, and from the second by its consistently monoecious habit and its lesser dimensions

Collected on permanently flooded ground of rice farms, near Chungking, Szechwan, West China, by the writer, Feb , 1932 Type in the collections of C C Jao and Herb Univ Mich , Nos S316 02, 03, 04, and 05

The writer is indebted to Professor W R Taylor for his direction throughout the preparation of this paper, to Professor L H Tiffany, whose advice, based upon an extensive familiarity with the genus, has been of the greatest value, and to other friends for their help in collecting specimens for him

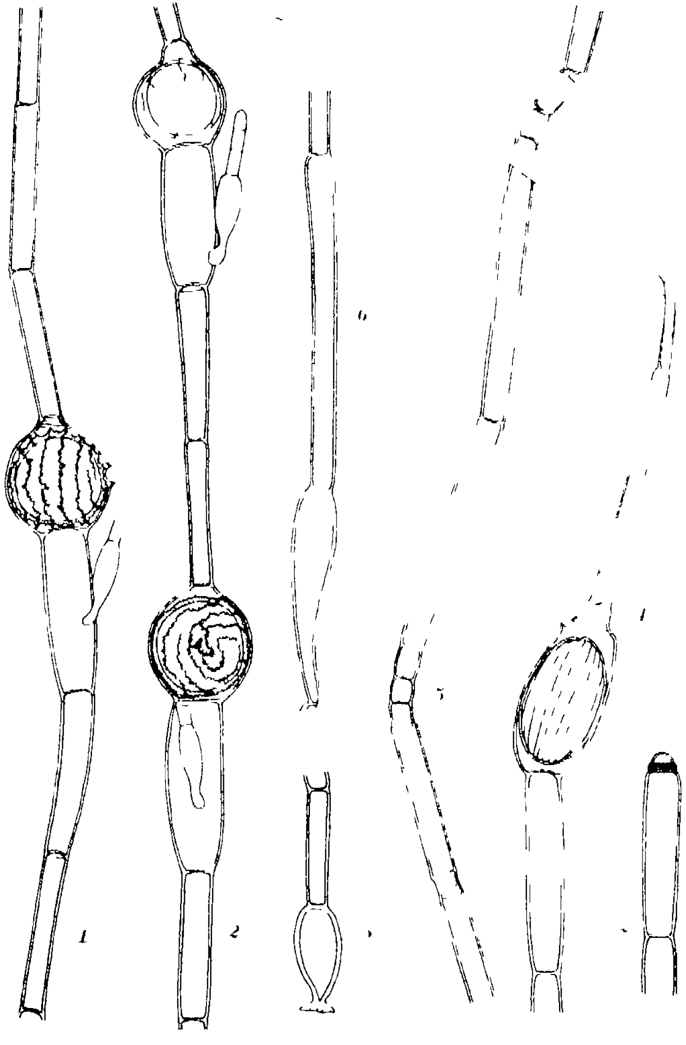
University of Michigan

EXPLANATION OF PLATE V

Figs 1–3 *Oedogonium spiralidens*, sp nov (× 360) Figure 1, a part of the filament, with one oögonium containing a mature oöspore in lateral view and a dwarf male on the suffultory cell, Figure 2, both mature (lower) and immature (upper) oögonia, the mature oöspore is seen in polar view, Figure 3, basal cell short and swollen

Figs 4–7 *Oedogonium orientale*, sp nov (× 360) Figure 4, an upper part of the filament, showing one mature oögonium and the terminal hyaline seta, Figure 5, a part of the male filament with scattered antheridia, Figure 6, a lower part of the filament, with an elongate vegetative cell and a swollen basal cell, Figure 7 terminal cell, apically obtuse

PLATE V



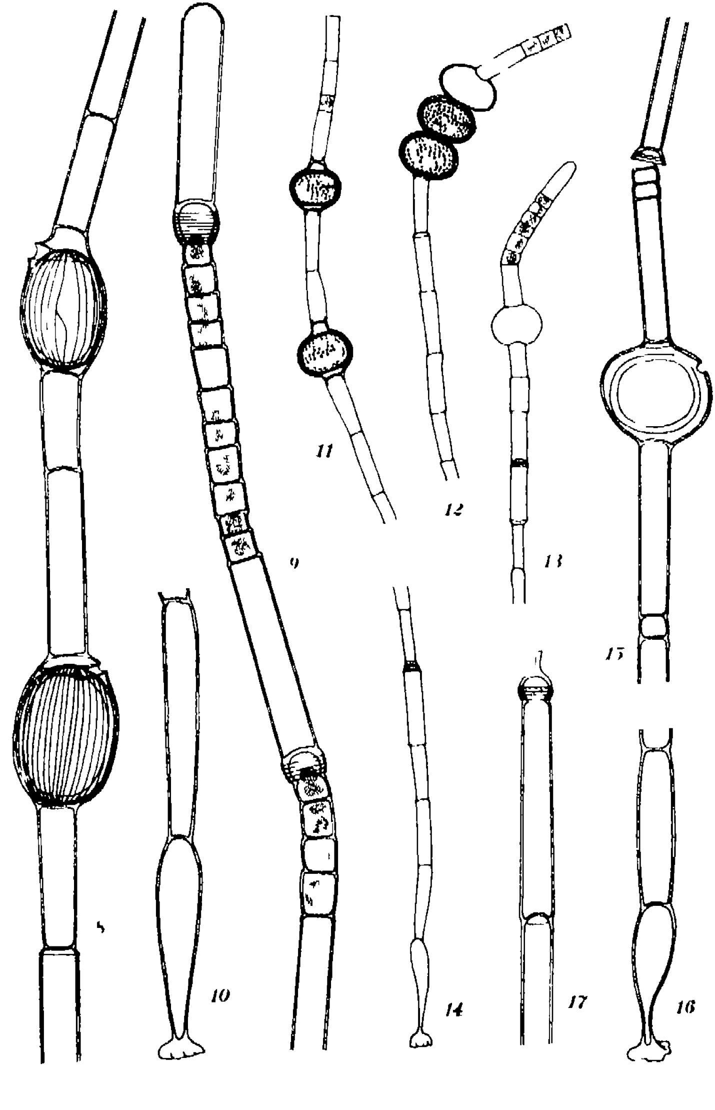
EXPLANATION OF PLATE VI

FIGS 8–10 *Oedogonium costatosporum* sp nov (× 360) Figure 8 part of a filament with two mature oogonia the arrangement and number of the ribs of the upper one are not of common occurrence in this species Figure 9 an upper part of the filament showing the terminal cell and two series of antheridial cells Figure 10 basal cell

FIGS 11–14 *Oedogonium cymatosporum* Wittrock & Nordstedt var *chungkingense* var nov (× 360) Figure 11 a part of the filament with two mature oogonia and a subepigynous antheridium Figure 12 a part of the filament with three oogonia in a group and three subepigynous antheridia Figure 13 end of the filament showing the terminal cell and six subepigynous antheridia Figure 14 a lower part of the filament showing the elongate and swollen basal cell with a large hapteron and the variability in cell diameter and form of the vegetative cells

FIGS 15–17 *Oedogonium intermedium* Wittrock var *szechwanense* var nov (× 360) Figure 15 a part of the filament with one mature oogonium and two subepigynous and one subhypogynous antheridia Figure 16 basal cell Figure 17 terminal cell showing the apiculate end

PLATE VI

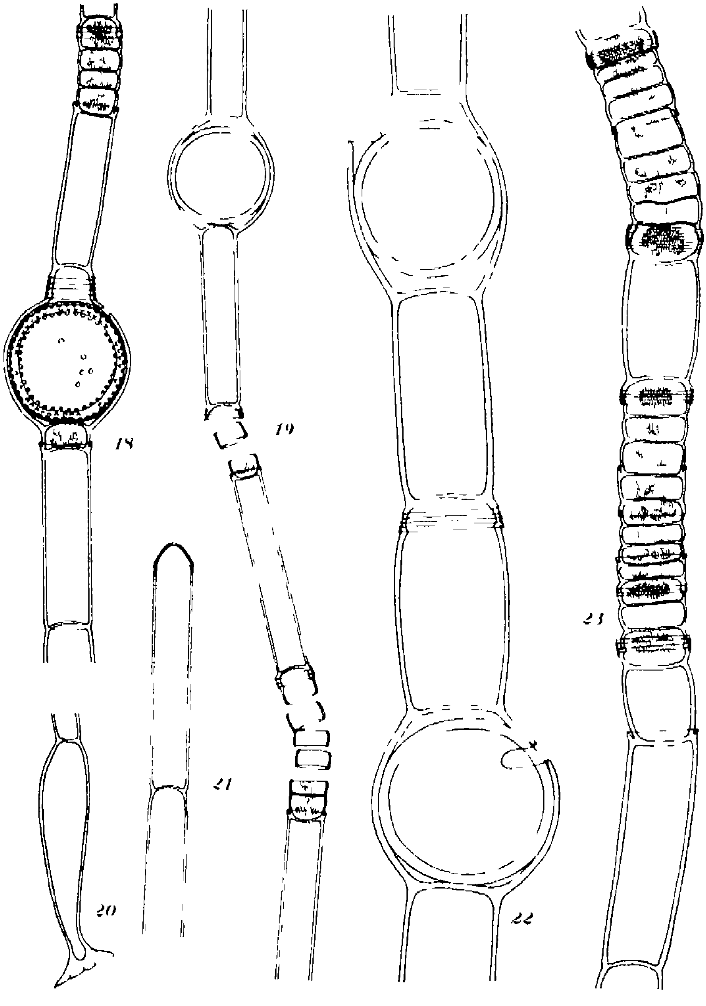


EXPLANATION OF PLATE VII

FIGS. 18–21. *Oedogonium excavatum* sp. nov. (× 360). Figure 18, a part of the filament showing a mature oogonium and the subepigynous and sub-hypogynous antheridia. Figure 19, a young oogonium and the scattered antheridia. Figure 20, obtuse terminal cell. Figure 21, elongated basal cell showing the habit of attachment.

FIGS. 22–23. *Oedogonium crassum* (Hassall) Wittrock var. *orbiculare* var. nov. (× 360). Figure 22, filament with two mature oogonia. Figure 23, male filament with two series of antheridia.

PLATE VII



NOTES ON NEW OR UNUSUAL MICHIGAN DISCOMYCETES I *

BESSIE B KANOUSE

THE following list comprises eighty-eight species of Discomycetes which, so far as the author has been able to determine from the records in the Herbarium of the University of Michigan, have not been previously reported from Michigan or which are otherwise of peculiar interest One new species, *Psilopezia albida*, is described A large number of the commonly collected species are omitted, regardless of the fact that they may not have been included in previously published lists

Unless a statement to the contrary is made, the author is responsible for the identifications The name of the collector appears after each collection The specimens mentioned have been deposited in the Herbarium of the University of Michigan by the following collectors E B Mains, A H Smith, G B Cummins, C H Kauffman, and B B Kanouse, and by others named in the text

A number of papers contain records of Discomycetes found in Michigan Longyear (13), Kauffman (5–12), Povah (17–19)

The author wishes to acknowledge with thanks the help of Dr E B Mains and of Mr Alexander Smith, who provided the photographs

Phaciciaceae

Keithia thujina Durand — On *Thuja occidentalis* L, Copper Harbor, Sept, 1930, collected by M L Gardner and identified by G B Cummins

Pyrenopezizeae

Pyrenopeziza nigrella Fuck. — On decaying stems, Lakeland, June, 1930, Kanouse

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No 413

DEMATEACEAE

VELUTARIA RUFO-OLIVACEA (A & S) Fuck — A single collection of this rare fungus was made near Ann Arbor, July, 1930, by Kanouse It grew on wet remains of wood on the ground The asci and spores are slightly smaller than Rehm's description calls for In our plants, which were compared with those at the British Museum, the asci are 75–85 × 5 7 μ, the spores, 7–12 × 5 μ Boudier (1, Pl 558) gives an accurate illustration

PATELLARIACEAE

DURELLA COMPRESSA (Pers) Fuck — On *Acer sp*, Ann Arbor, April, 1929, on *Robinia sp*, Ann Arbor, Nov, 1929 Both collections were made and identified by Cummins

CATINELLA NIGRO-OLIVACEA (Boud) Durand — One fine collection was made on wet, rotting logs, Ann Arbor, Oct, 1931, by Mains The reader is referred to Durand (3) for a detailed discussion of this genus and to Boudier (1, Pl 452) for an excellent illustration

BULGARIACEAE

ORBILIA BOTULISPORA Von Höhn — Collected on oak, Ann Arbor, Oct, 1928, Kanouse

ORBILIA CHRYSOCOMA (Bull) Sacc — On elm log, Ann Arbor, Oct, 1928, collected and identified by Cummins, Ann Arbor, Oct, 1931, Kanouse

ORBILIA CHRYSOCOMA (Bull) Sacc var MICROSPORA Sacc — Hillsdale Co, May, 1922, R Hayes, Ann Arbor, Nov, 1928, collected by Kauffman and identified by Cummins, Ann Arbor, July, 1930, Smith

ORBILIA CURVATOSPORA Boud — Ann Arbor, July, 1921, collected by Kauffman and identified by Cummins, Hillsdale Co, May, 1932, collected by Hayes and identified by Cummins

ORBILIA LEUCOSTIGMA Fr — On very rotten wood, Quincy, Sept, 1928, Kanouse, Lakeland, June, 1930, Kanouse

ORBILIA LEUCOSTIGMA Fr var XANTHOSTIGMA (Fr) Rehm — Ann Arbor, July, 1930, collected by Smith and identified by Kanouse, Stockbridge, July, 1930, Kanouse

ORBILIA LUTEORUBELLA (Nyl) Karst — Rock River, Sept, 1927, Kanouse, Ann Arbor, Nov, 1928, collected by M L Lohman

and identified by Cummins, Bronson, July, 1930, Kanouse, Ann Arbor, Nov, 1931, Kanouse

ORBILIA RUBELLA (Pers) Karst — One collection from Ann Arbor, July, 1930, Smith Nannfeldt (15) calls this *Hyalina rubella* (Fr) Nannf

ORBILIA SARRAZINIANA Boud — On dead wood, Stockbridge, July, 1930, Smith See Boudier (1, Pl 462)

ORBILIA VINOSA (A & S) Karst — Stockbridge, Oct, 1928, Kanouse, Stockbridge, Oct, 1929, collected and identified by Cummins

OMBROPHILA SUBSQUALLIDA Rehm — On mats of leaves of *Populus sp*, Ann Arbor, June, 1930, Kanouse

OMBROPHILA VIOLACEA (Hedw) Fr — One collection, Pinckney, Oct, 1930, Kanouse

BULGARIA MELASTOMA (Sow) Seaver — Burt Lake, Cheboygan Co, June, 1932, Mains and Smith A collection made at Bay View, Aug, 1905, was reported by Kauffman (5) as *Plectania hirtipes* Sacc

HOLWAYA GIGANTEA (Pk) Durand — This fungus is frequently seen in the autumn on moss-covered logs in wet woods Ann Arbor, 1910, Kauffman, Stockbridge, Oct, 1929, Kanouse and Cummins

CENANGIACEAE

STAMNARIA AMERICANA Massee & Morgan (Pl VIII) — This species was found by Smith and Mains growing in great abundance on *Equisetum sp*, Ann Arbor, Nov, 1931 Included among the collections is one made in the winter, Dec, 1932, by Mains Nannfeldt (15) considers it probable that the American species is the same as the European *Stamnaria Equiseti* (Hoff) Rehm However, as Seaver (23) has pointed out, the spores as well as the asci of the American plants are considerably larger than those reported for the European species, and it seems quite possible that two species are involved The conidial stage, *Gloeosporium Equiseti* E & E, has been collected near Ann Arbor

MOLLISIACEAE

MOLLISIA BENESUADA (Tul) Phill — On wet wood, Ann Arbor, Oct, 1928, Kanouse, Ann Arbor, July, 1929, Kauffman, Pinckney, Oct and Nov, 1930, Mains.

MOLLISIA BENESUADA (Tul) Phill var POLYSPORA Kauff — On

rotting wood This variety, which was described by Kauffman (12) from specimens collected at Rock River, was found at Stockbridge, Aug, 1928, by Kanouse and E G Whitney, and also at Marquette, Sept, 1932, by Mains

MOLLISIA CAESPITOSA Karst — On elm wood, Ann Arbor, Oct, 1929, collected and identified by Cummins

MOLLISIA CULMINA (Sacc) Rehm var CARICINA (Sacc) Rehm — Commonly found in the autumn on the basal sheaths and culms of *Carex spp* in the swamps of southern Michigan The apothecia grow thickly, forming conspicuous patches Ann Arbor, Oct, 1931, Kanouse, Pinckney, Oct and Nov, 1931, Mains, Pinckney, Oct, 1932, Kanouse

MOLLISIA MELALEUCA (Fr) Sacc — This beautiful little Mollisia is collected infrequently, but has been found on rotten wood in both the Upper and Lower Peninsulas of Michigan Ann Arbor, Sept, 1930, Smith, Rock River, Sept, 1932, Mains

TAPESIA SECAMENTI Fairman — This fungus was found on dead wood near Stockbridge, Nov, 1930, Kanouse Fairman (4) collected at Lyndonville, New York, on chips of *Betula sp*, the specimens from which he described the species Our plants correspond well with his description

BELONIUM DELITSCHIANUM (Auersw) Rehm — On rotten log, Steere's swamp, Ann Arbor, Nov, 1931, Mains Rehm gives the host as *Scirpus lacustris*, but even though our plants occurred on a different substratum the characters of the two collections seem to agree The spores of our plants are 4-celled and measure 25–40 × 6–7 μ

PEZIZELLA HYALINA (Pers) Rehm — On dead twigs, Ann Arbor, May, 1930, Kanouse

PEZIZELLA PUBERULA (Lasch) Rehm — On oak leaves, Ann Arbor, Oct, 1928, collected and identified by Cummins, Ann Arbor, July, 1930, Kanouse

PEZIZELLA PUNCTIFORMIS (Grev) Rehm One collection on fallen elm leaves, Stockbridge, Oct, 1928, Kanouse

PEZIZELLA TUMIDULA (Rob & Desm) Sacc — On oak leaves, Ann Arbor, 1928, collected and identified by Cummins

PEZIZELLA TURGIDELLA (Karst) Sacc — On *Carex sp*, Ann Arbor, Oct, 1928, on *Typha sp*, Pinckney, Oct, 1928 Both collections made and identified by Cummins

HELOTIACEAE

ARACHNOPEZIZA AURELIA (Pers) Fuck — This beautiful little plant has been found frequently Lima Center, May, 1909, Kauffman, Chelsea, May, 1909, Kauffman, Ann Arbor, May, 1917, Kauffman, Stockbridge, Nov , 1931, Kanouse, Pinckney, May, 1932, Kanouse and Smith It was reported by Kauffman (8)

PHIALEA ACUUM (A & S) Rehm On tamarack needles, Mud Lake Bog, near Ann Arbor, May, 1930, Smith Our plants appear to fit exactly the description given by Rehm (20)

PHIALEA RUBICOLA Sacc — On blackberry canes, Ann Arbor, Oct , 1928, collected and identified by Cummins

PHIALEA SUBGALBULA Rehm — Collected twice at Ann Arbor, Steere's swamp, Nov , 1931, Mains, Herron's woods, Nov , 1931, Kanouse Our plants agree well with Rehm's Ascomyceten No 1981, with which they have been compared

CYATHICULA CORONATA (Bull) De Not — Found twice in Washtenaw Co , Oct , 1928, and Sept , 1929, collected and identified by Cummins

SCLEROTINIA ERYTHRONI Whetzel — Found on bulbs of *Erythronium americanum* Ker , Ann Arbor, May, 1932, collected by G B Fischer and A H Smith

CIBORIA LUTEOVIRESCENS (Rob) Sacc — One collection from Stockbridge, Aug , 1928, Kanouse

RUTSTROEMIA NEBULOSA (Cke) Kauffman & Kanouse — Previously reported by Kauffman (12) from Rock River Found widely distributed in Michigan Stockbridge, Aug , 1928, Kanouse, Rock River, Sept , 1929, Kauffman and Smith, Pinckney, 1931, Smith, Ann Arbor, 1932, Smith, Munising, Au Train, and Rock River, Aug , 1932, and Marquette, Sept , 1932, Mains

HELOTIUM CONFORMATUM Karst — Wayne Co , 1928, Kanouse, Ann Arbor, Oct , 1928, collected and identified by Cummins, Harbor Springs, June, 1932, Mains

HELOTIUM HERBARUM (Pers) Fr — Ann Arbor, Oct , 1928, collected and identified by Cummins, Ann Arbor, Oct , 1931, Mains

HELOTIUM IMBERBE (Bull) Fr — New Richmond, Sept , 1910, Kauffman, Washtenaw Co , 1928, collected and identified by Cummins, Pinckney, May, 1932, J L Lowe, Harbor Springs, June, 1932, Smith

HELOTIUM SCUTULA (Pers) Karst — Whitmore Lake, Oct , 1928, collected and identified by Cummins, Ann Arbor, Nov , 1931, Mains, Pinckney, Oct , 1931, Mains, Au Train and Rock River, Aug , 1932, Mains

HELOTIUM SUBLENTICULARE Fr — Au Train and Munising, Aug , 1932, Mains

HELOTIUM VIRGULTORUM (Vahl) Phill var FRUCTIGENUM Phill — Commonly seen in late summer and autumn on shells of nuts, acorns, twigs, etc Ann Arbor, Sept , 1928, collected and identified by Cummins, Stockbridge, Oct , 1928, Kanouse, Ann Arbor, July, 1929, Kauffman, Ann Arbor, Nov , 1930, Mains and Kanouse, Ann Arbor, Nov , 1930, Smith, Ann Arbor, Sept , 1932, J V A Drummond

HELOTIUM VITIGENUM De Not — On grape stems, Ann Arbor, Oct , 1928, collected and identified by Cummins

LACHNELLULA THEOIDEA (C & E) Sacc — On sticks, Chelsea, April, 1929, collected and identified by Cummins

LACHNUM ASPIDII (Lib) Karst — On dead stems of *Adiantum pedatum* L , Ann Arbor, May, 1929, Kanouse

LACHNUM SPIRAEAECOLUM (Karst) Rehm — At base of stems of some shrub, Ann Arbor, July, 1921, collected by Kauffman and identified by Cummins

ERINELLA NYLANDERI Rehm — Found in quantity on dead stems of *Urtica dioica* L in a low wet woods, Ann Arbor, Oct and Nov , 1931, Mains and Kanouse

PEZIZACEAE

PSEUDOPLECTANIA NIGRELLA (Pers) Fuck — Four collections were made in the state in 1932 Topinbee and Harbor Springs, June, Mains and Smith, Rock River, Aug , Mains, Ann Arbor, May, Mains and Smith

LAMPROSPORA TRACHYCARPA (Curr) Seaver — Found in the area of burned-over tamarack, black spruce, and sphagnum bog at Mud Lake, near Ann Arbor, Oct and Nov , 1931, Mains and Smith This species, together with others mentioned in this paper as having been collected from this bog, appeared immediately following the burn The soil and débris retained the heat until early winter, consequently, collections were made much later in the season than is usual in this locality Nearly thirty acres

were destroyed and patches of Discomycetes were conspicuous features of the bog With the exception of *Geopyxis cupularis* (L) Sacc , none of the Discomycetes that were found in the fall have reappeared since

ASCOBOLUS STRIISPORUS (Ellis & Dearness) Seaver — This rare fungus was found on decaying leaves, Ann Arbor, Oct , 1929, collected and identified by Cummins It is reported by Seaver (21) as having been collected twice in Canada This collection appears to be the first reported from the United States

ALEURIA WISCONSINENSIS Rehm — On the ground in open woods, Ann Arbor, May, 1931, Lowe Seaver gives the distribution in America as Wisconsin and Minnesota

ALEURIA RUTILANS (Fr) Gill — On wet soil, Ann Arbor, May, 1931, Mains, Marquette, Sept , 1932, Mains

ALEURIA ATROVINOSA (Cke) Seaver — A fine collection of this distinct species was made at Munising, Aug , 1932, by Mains

Psilopezia albida, sp nov — Apothecia gregarious, sessile, discoid to hemispherical, 2-4 mm wide, closely adhering to the substratum, surrounded by a sterile margin, parenchymatous, texture very soft waxy when wet, drying to a thin scale with a membranous border, hymenium plane, watery, dingy white, drying brown with a lighter brown margin, asci cylindric, 300–325 × 18–20 μ, spores ellipsoid, 1-seriate, lying with the long axis parallel to the length of the ascus when mature, smooth, thick-walled, containing a large oil drop that nearly fills the spore, colored faintly yellowish, 18 20 × 10–11 μ, paraphyses clavate, numerous, extending as much as 25 μ beyond the asci, reaching 6 μ in diameter at their apices, apices adhering closely together, contents not conspicuous Iodine colors the mature asci golden brown, the immature asci are blue in the uppermost one third, the paraphyses brownish

On wood of a deciduous tree submerged in running water Collected by E B Mains, No 32-646, September 8, 1932, Au Sable Falls near Grand Marais, Upper Peninsula, Michigan Type is deposited in the Herbarium of the University of Michigan

The color of the apothecia is the distinguishing character of this species Other species of this genus are some shade of brown or yellow, whereas this is grayish white The asci are also unusually large

Apothecia gregaria, sessilia, discoidea vel hemisphaerica, 2–4 mm lata, substrato tenaciter adhaerentia, margine sterili circumdata, textura parenchymatosa, molliter cerea, si modo siccata tenuiter laminiformia, membranaceo-marginata, hymenium planum, albidum vel siccitate brunneum, asci cylindrici, 300–400 μ longi, 18–20 μ crassi, sporae pallide flavidae, ellipsoideae, 18–20 μ longae, 10–11 μ crassae, monostichae maturitate longitudinaliter dispositae, laeves, crasse circumvallatae, conspicue uniguttatim oleiferae, paraphyses clavati numerosi, interdum ascis 25 μ longiores, apice 6 μ crassi etiamque inter se cohaerentes — Ad lignum arboris nonconiferae in aqua fluviali submersum, legit E B Mains, n 32–646, prope Grand Marais, Mich Specimen typicum in Herb Univ Mich conservatum est

PSILOPEZIA AQUATICA (DC) Rehm — On an old log in a bed of a stream, Chatham, Aug , 1932, Mains The large sculptured spores are very characteristic Iodine does not color the asci

PSILOPEZIA TRACHYSPORA E & E — Ann Arbor, Nov , 1931, Kanouse The spore measurements of the Ann Arbor plants agree with those given by Ellis and Everhart rather than with the much larger size ascribed to this species by Seaver

PSILOPEZIA NUMMULARIA Berk — On mossy log, Mud Lake Bog, near Ann Arbor, July, 1930, Smith, Duck Lake, Ann Arbor, Sept , 1930, Smith

HUMARINA OCHROLEUCA (Clements) Seaver — On burned ground, Mud Lake Bog, Ann Arbor, May, 1932, Smith and Mains The spore measurements are slightly smaller than those given by Seaver for this species They are 14–15 × 7–8 μ and are without oil drops The crenulate margin of the apothecium is very conspicuous

HUMARINA RUBENS (Boud) Seaver — Found on burned soil, Whitmore Lake, Ann Arbor, July, 1921, collected by Kauffman and identified by Cummins

HUMARINA LEUCOLOMA (Hedw) Seaver — Ann Arbor, July, 1930, Smith This collection was compared with Rehm's Ascomyceten No 351b

HUMARINA SEMIIMMERSA (Karst) Seaver — One collection was made near Ann Arbor on a pile of wet sand in a woods July, 1929, Kanouse and C A Brown

HUMARINA HEPATICA (Batsch) Seaver — This species occurred in

abundance in the burned area in Mud Lake Bog, Ann Arbor, Oct and Nov, 1931, Mains and Kanouse Seaver gives its American distribution as Colorado

HUMARINA TRACHYDERMA (E & E) Seaver — Pinckney, July, 1930, Smith, Ann Arbor, May, 1930, and Sept, 1932, Kanouse

THECOTHEUS PELLETIERI (Crouan) Boud — Stockbridge, Oct, 1928, collected and identified by Cummins

OTIDEA LEPORINA (Batsch) Fuck — This species is not often collected in Michigan, although it has been found widely distributed throughout the state It was reported by Kauffman (8) and was collected by him at Marquette, Sept, 1906, and at Presque Isle, Aug, 1909, Kauffman and Taylor, New Richmond, Sept, 1910, Kauffman Rock River, Sept, 1932, Mains, Deerton, Sept, 1932, Mains All the plants in these collections have the flattened-split apothecia rather than the erect apothecia which are usually characteristic of species of this genus Rehm (20) mentions this peculiarity

OTIDEA LEPORINA Fuck var MINOR Rehm — One collection of this variety was made at Rock River, Aug, 1932, by Mains The plants are 1 cm in height, with erect apothecia and split on one side to the base They are much smaller than *Otidea leporina* They correspond well with Rehm's description

OTIDEA CONCINNA (Pers) Rehm — The herbarium contains one excellent collection made at Ann Arbor, July, 1915, by Kauffman His notes on the fresh plants give the color as "yellowish buff throughout" A second collection was made at Ann Arbor, July, 1929, by Smith Our plants are like those found in Rehm's No 1638, with which they have been compared Seaver does not list this species from North America

OTIDEA PHLEBOPHORA (B & Br) Sacc A collection of this species was made at Chelsea, Aug, 1915, by Kauffman and Mains Notes made by Dr Mains when the plants were fresh give the following data "The apothecia measure 1 4 cm in diameter, and are deeply split down to the base on one side The basal portion is subplicate and has a decidedly ridged effect The spores measure 8–10 × 4–5 μ" The filiform paraphyses are numerous and are not enlarged at their apices Not all of them are curved The plants were growing among moss A second collection, made at Ann Arbor, June, 1894, by L N Johnson

and identified by J B Ellis as *Peziza euplecta* Cke, is also referable here Reported by Kauffman (11) The pits at the apices of the ridges on the stem as emphasized by Massee (14) in his redescriptions of Berkeley's fungi are easily seen in our Michigan plants

PAXINA SEMITOSTA (Berk & Curt) Seaver (Pl IX) — This species has been collected at intervals throughout a period of twenty-one years on a wet clay bank of a ravine, Ann Arbor The photograph was made from a collection of October, 1932, by Smith

GEOPYXIS CUPULARIS (L) Sacc (Pl X) — Found in the burned bog area at Mud Lake, Ann Arbor, Oct to Dec , 1932, by Smith, Mains, and Kanouse, and again in the following spring There seems to be a very wide range in the size and color of this species The apothecia of our plants measured 2½ 3 cm in diameter, and many of them had stems as much as 1 cm in height These sizes are for a much larger plant than is usually reported for this species The color of our fresh plants was "pinkish cinnamon"[1] and "orange-cinnamon" to "vinaceous-cinnamon," drying "Sayal brown" to "Mikado brown" The outside of the apothecia is concolorous or darker Dodge (2) gives the color of the Wisconsin plants as "usually alutaceous and only occasionally egg-yellow" The paraphyses are slender and are not thickened at their apices Reported by Kauffman (11)

GEOPYXIS VULCANILIS (Peck) Sacc — Found in small numbers in the same location with the preceding species, May, 1932, Smith

RHIZINA INFLATA (Schaeff) Karst (Pl XI) — This rare species grew in great abundance in the burned bog at Mud Lake, Ann Arbor It was collected repeatedly throughout the autumn of 1931 by Smith, Mains, Kanouse, and others It occurred in such quantities that several pecks could have been obtained It has not since been discovered in the bog Interesting questions arise, such as Where did the spores come from that caused such a widespread occurrence of the fungus in the bog? How long will the spores of this crop remain viable? If the spores that caused the present outbreak depended upon the heat for germination, then they must have been dormant in the soil for a long time, since no fire has occurred in the swamp for the past fifteen years

[1] The colors are those of Ridgway, *Color Standards and Color Nomenclature*

DISCINA ANCILIS (Pers) Sacc — Ann Arbor, May, 1914, Mains, Harbor Springs, June, 1932, Mains, Wilderness Park, June, 1932, Mains and Smith, Cross Village, June, 1932, Mains

PEZIZA EMILEIA Cke — This is apparently a rare species in America Dodge reported it from Wisconsin It was found at Ann Arbor, July, 1929, by Smith Boudier's plate 280 (1) represents this species as we know it from our specimens

PEZIZA PROTEANA (Boud) Seaver — A large collection of this species was made at Ann Arbor, Oct , 1932, by C W Griffin It was found on burned ground and wood remains The small spores and white apothecia are the distinguishing characters

PEZIZA VENOSA Pers — On the ground in low, wet, deciduous woods, Ann Arbor, May, 1932, G W Fischer It occurred in the same woods throughout the spring in considerable numbers Seaver (21) says of it, "not very commonly collected "

PEZIZA ABIETINA Pers — One collection was made at Rock River, Aug , 1932, by Mains This species could easily be confused with the otideas on account of the hooked paraphyses and the small biguttulated spores The apothecia, however, are not split A collection from Isle Royale, 1904, made by Harper, was identified by Rehm as *Plicaria rubrofusca* Rehm Seaver puts this species in synonymy with *P abietina* Although I have not seen Harper's specimen, it seems possible that his fungus is different from *P abietina* Rehm's description and figure of *Plicaria rubrofusca* do not emphasize the peculiar knotted and hooked paraphyses that are so conspicuous in *P abietina* Boudier's plate 333 (1) figures the paraphyses as we find them in the specimens from Rock River

PEZIZA VIOLACEA Pers — Ann Arbor, July, 1930, Smith, Mud Lake, Oct , 1931, Mains and Kanouse, Ann Arbor, Nov , 1931, Mains, Munising, Sept , 1932, Mains, Rock River, Aug , 1932, Mains, Harbor Springs, Sept , 1932, Mains, Ann Arbor, May, 1932, Smith and Mains

PEZIZA CLYPEATA Schw — Frequently seen in the woods in the autumn on very rotten logs Ann Arbor, Oct , 1907, Kauffman, Stockbridge, Oct , 1928, Kauffman and Kanouse, Ann Arbor, Oct , 1929, E G Kauffman, Stockbridge, Nov , 1930, Mains and Kanouse, Harbor Springs, Sept , 1931, Mains, Stockbridge, Sept , 1932, Mains, Rock River and Au Train, Aug , 1932, Mains

Sarcosphaera funerata (Cke) Seaver — Found in sand at the shore of Deer Lake near Rock River, Sept , 1932, by E E and L B Mains Seaver, in comments accompanying a report by West (24), gives interesting data concerning the American collections He mentions a collection from Albion, which is the only other known Michigan record for this interesting and rare fungus

Galactinia celtica Boud — Our specimens were found on the ground among moss, Ann Arbor, Aug , 1929, by Smith The color is violet throughout The large rough spores and the filiform paraphyses distinguish it at once from *P violacea*, with which it might be confused on account of the color The spores measure 17 20 × 8 11 μ Boudier (1, Pl 289) gives an excellent illustration

Helvellaceae

Helvella sphaerospora Pk (Pl XII) Beautiful specimens of this remarkable fungus were collected at Harbor Springs, June, 1932, by Smith and Mains Notes made by Mr Smith on the fresh plants give the measurements of the pilei as 7–14 cm broad, and the stipe as 5 7 × 3–6 cm long, deeply fluted, and lacunose They were growing on an old stump

Corynetes robustum Durand — On wet ground under hemlocks, Rock River, Sept , 1929, collected and identified by Smith

Of Uncertain Position

Ascotremella faginea (Pk) Seaver — An excellent specimen of this unusual fungus was made at Rock River, Sept , 1929, by Smith This collection adds to the records of distribution of this remarkable species, since Seaver (22) gives the American distribution as New York and Ontario

University of Michigan

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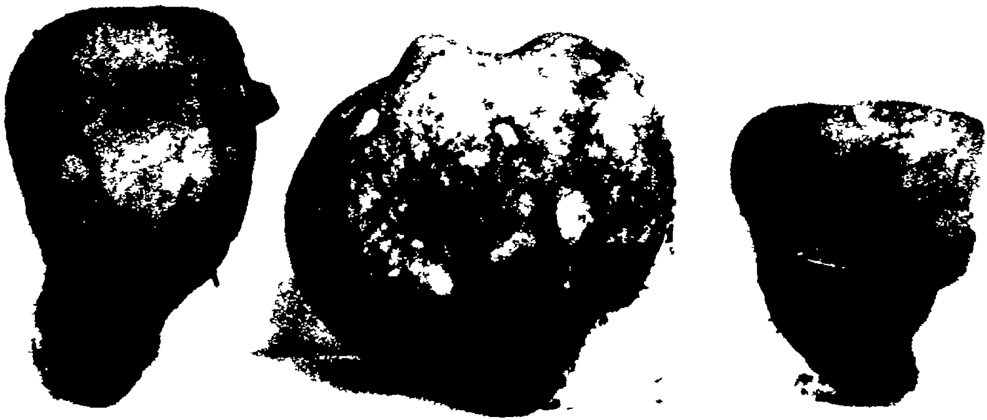
PLATE VIII

americana Masses and M

PLATE IX



Emnt emt ti Berk & Cult Se ve

PLATE X

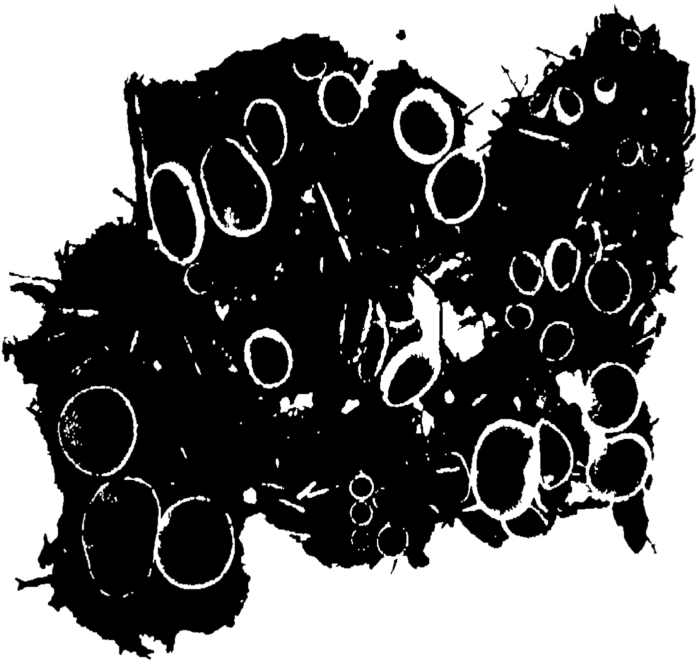


PLATE XI

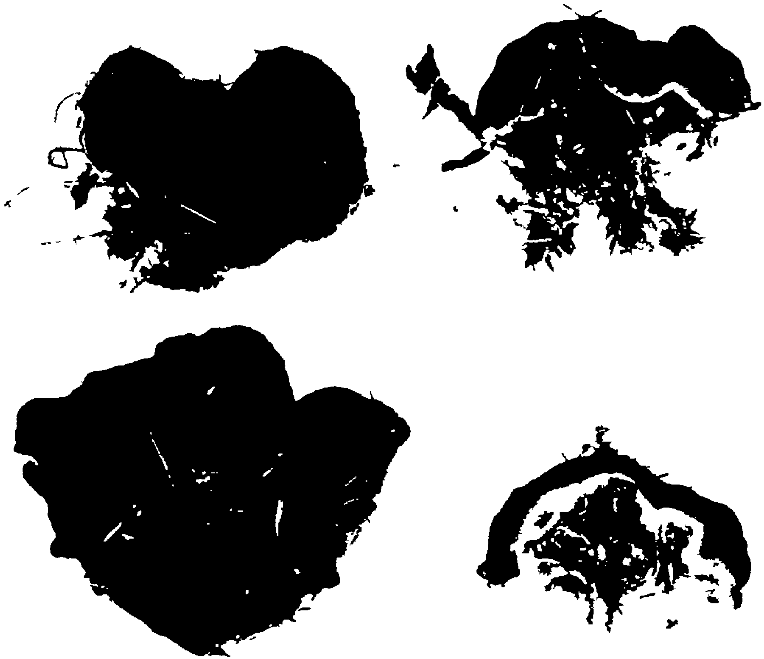


PLATE XII

Helvella sphaerospora Pk.

FOREST DISTRIBUTION IN SOUTHWESTERN MICHIGAN AS INTERPRETED FROM THE ORIGINAL LAND SURVEY (1826–32)

LESLIE A KENOYER

THE original survey of the counties of southwestern Michigan was made just over a century ago (1826 to 1832) The surveyor blazed two trees at each section corner and at the midpoint of each section boundary line, stating in his field notes the kind, size, and location with reference to the stake When records of the species are inserted in their proper locations on the county map, it is easy to outline the area occupied by each plant association Since the located points are in general a half-mile from one another, it is possible to draw the boundary line of the associations within a half-mile of its exact location The vegetation map constructed from timber now standing would be less accurate, since standing woodlots are generally farther apart than this, and the labor involved would be considerably greater As was indicated from the comparison in Kalamazoo County of observed timber with that noted in the survey,[1] present distribution is essentially the same as that of a century ago

Examination of records at the courthouses of six counties furnished the data for the construction of Map 2 The plant associations indicated are beech-maple, oak-hickory, oak-pine, dry prairie, and lake and swamp The map also shows the distribution of hemlocks in the beech-maple association, and the distribution of white pines in the associations in which they occur

The beech-maple and the oak-hickory are the most extensive associations of the area In general, the former occupies soils richer in mineral matter and better suited for the accumulation of humus,

[1] Kenoyer, Leslie A, "Ecological Notes on Kalamazoo County, Michigan, Based on the Original Land Survey," *Pap Mich Acad Sci, Arts and Letters*, 11 (1929) 211–217 1930

the latter, the poor soils of the sandy or gravelly type A comparison of this map with Leverett's geological map [2] shows that in the middle portion of the area, as in the eastern part of Van Buren County, there is a marked tendency for beech and maple to grow particularly on the till plains, also on the terminal moraines, and for oak and hickory to grow on the outwash plains Toward Lake Michigan (westwardly) and toward the north, where relative humidity is greater, there is an increasing tendency for beech to occur on the outwash and other poor soils, whereas farther from the lake (eastwardly) or toward the south, the terminal moraines and the till plains are increasingly given over to oak It will be noted in Table I

TABLE I

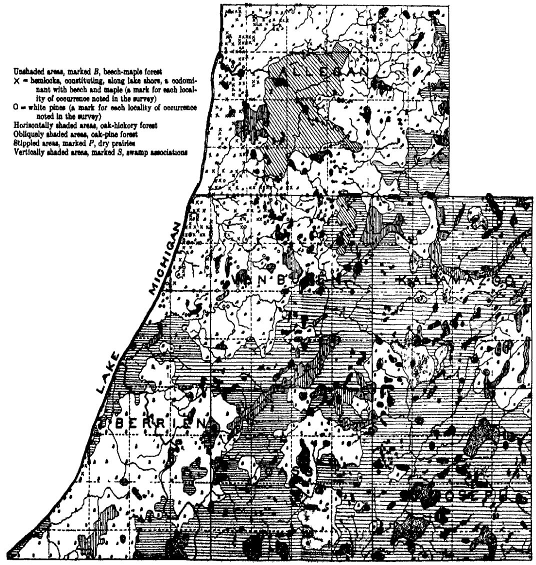
PERCENTAGE DISTRIBUTION OF PLANT ASSOCIATIONS FOR THE SIX COUNTIES REPRESENTED ON THE MAP

Averages for the three counties bordering Lake Michigan are compared with those for the three counties remote from the lake

	Beech-maple	Beech maple with hemlock	Oak hickory	Oak pine	Dry prairie	Lake and swamp
Allegan	51	18	8	16	0	7
Van Buren	40	15	33	3	0 2	9
Berrien	62	0	32	0	1	5
Cass	28	0	59	0	4	9
Kalamazoo	23	0	56	0	8	13
St. Joseph	5	0	76 5	0	11 5	7
	51	11	24	6	0 4	7
	19	0	64	0	6	10

that there is a great preponderance of the beech-maple type in Allegan County and of the oak-hickory type in St Joseph County, with an intermediate condition in the intervening counties The summary for the three counties bordering the lake shows a decidedly higher percentage of beech and a decidedly lower percentage of oak and of prairie than are found in the three remote from the lake It cannot be asserted, however, that the contrast is wholly a matter of differences in atmospheric humidity Soil conditions as well as

[2] Leverett, Frank, Map of the Surface Formations of the Southern Peninsula of Michigan Michigan Department of Conservation 1924



MAP 2 FOREST ASSOCIATION MAP OF SOUTHWESTERN MICHIGAN

invasional history doubtless enter into the problem It is probable that the counties east of Kalamazoo and St Joseph would show a higher percentage of beech and a lower percentage of oak than do these counties According to the Leverett map, however, there are few, if any, counties in the state that have a higher proportion of glacial outwash than do Kalamazoo and St Joseph

Interest in the problem of the existence of a lake forest, with hemlock and white pine as dominants, as postulated by Weaver and Clements,[3] drew attention particularly to the counties bordering the lake Hemlock and white pine in the region studied are limited to a triangular area about the width of Allegan County, thirty-six miles on the north, and narrowed to a tail-like strip of a width of a mile or two next the lake in Berrien County Of the two species, hemlock is particularly restricted to the vicinity of the lake, where 85 per cent of the hemlocks used as witness trees are within ten miles of the shore

In Allegan County is an old lake plain occupying an area some twelve by sixteen miles It was doubtless an arm of Lake Michigan Its timber was a mixture of white pine and white oak Sawmills flourished here in the 'eighties, removing the pines and thereby giving the oaks a certain advantage This area has around its borders an almost continuous ridge of well-marked sand dunes supporting in part the plant species characteristic of the lake-shore dunes The soil of the plain is barren and abounds in deserted farm homes, and in shanties that harbor an economically distressed population Its flora is unique for the region, including such unusual forms as sweet fern, perennial ragweed, whorled milkweed, prickly pear cactus, *Geum triflorum*, and *Koeleria cristata*

The pines of southwestern Michigan are nearly all *Pinus Strobus* There are a few trees of *Pinus resinosa* at Palisades Park, Van Buren County *Pinus Banksiana* has not been reported from the area here considered, although it is found along the lake shore immediately north of this area, in Ottawa County, and immediately south, in La Porte County, Indiana White pine is associated with either beech or oak, or occurs as a hydrarch pioneer in the swamp forest or as a xerarch pioneer on exposed sandy areas In Van Buren County the survey shows fifty-five pines in areas mapped as beech, twenty-

[3] Weaver John E, and Clements, Frederic E *Plant Ecology* (New York, 1921), pp 440-443

six in areas mapped as oak, and six in areas mapped as swamp The few pines in Kalamazoo County are mainly in swampy areas, with tamarack as their most conspicuous associate In Allegan County, as was stated above, most of the pines are associated with white oak on barren sandy soil Hemlock is rarely found apart from its associates, hard maple and beech So, however we may interpret the great body of coniferous forest in the Great Lakes area, the distribution of white pine and hemlock toward their southern limits would not indicate that they are closely associated as climax codominants

All these counties are occupied by numerous kettle-hole lakes and swamps The moister parts of these are generally occupied by strictly aquatic vegetation, with sedge meadows in the slightly drier parts A still drier condition favors tamarack, whereas outside this there is usually a swamp forest characterized by black ash, yellow birch, black gum, red maple, and elms Since the beech-maple forest is adapted to lands rich in humus and with high humidity, it usually follows the swamp forest without any intervening oak stage Kalamazoo County has a slightly larger area of lake and swamp than do the other counties studied, probably because of rather extensive belts of poorly drained land along the Kalamazoo River

Prairies were rather conspicuous features of the counties more remote from the lake, St Joseph County having the largest prairie area The only trees in these areas were rather sparsely scattered bur oaks. In many instances these were so far apart that the surveyor located the corner, without reference to trees, by means of a stake driven into a mound raised in the prairie The counties bordering the lake are almost without these prairies It is known that in some places, as in the city of Chicago, prairie areas were once extensive undrained marshes, with the grasses following the sedges in succession Veatch,[4] however, cites evidence that the soil of the Michigan prairies developed under conditions of medium or low-moisture content, and regards them as relicts of a more extensive prairie flora dating from a time in which climatic conditions were more xeric than at present The same idea is stated by Weaver and Clements[5] as follows "The subclimax prairie in general represents an eastward movement of the climax prairie into the region of

[4] Veatch, J O, "The Dry Prairies of Michigan," *Pap Mich. Acad Sci., Arts and Letters*, 8 (1927) 269–278. 1928.

[5] Weaver and Clements, *op cit*, pp 462–463.

deciduous forest, as the latter retreated in consequence of reduced rainfall. The reciprocal withdrawal of the grasses did not take place, partly because they adjusted themselves to the increasing rainfall, but chiefly because their competition with the seedling trees prevented anything more than an exceedingly slow advance of the latter. As a consequence, this subclimax has persisted for thousands of years as a great grassland triangle in the heart of the oak-hickory forest. During this time small portions of it along the margin and at the tip have been regained by forest, as the relict outposts of prairie in Ohio and Michigan show."

Unfortunately, the flora of the southwestern Michigan dry prairies has been almost destroyed by tillage. It includes *Eryngium yuccifolium, Cacalia tuberosa, Silphium terebinthinaceum, Amorpha canescens, Asclepias verticillata, Petalostemum purpureum, Viola pedata, Hypoxis hirsuta*, and *Sisyrinchium albidum*.

Probably but few of the witness trees are now standing. The surveyor of Cass County informs me that at one section corner two bur oaks which measured eight and ten inches in diameter when used as witness trees now have diameters of thirty-three and thirty-six inches respectively.

The writer is convinced that the most accurate picture of plant distribution before the settlement of the country can be obtained from the study of survey records as indicated. He is indebted to the several county surveyors or registers of deeds for permission to assemble the data, and to two of his students, Florence Haas and Cecil Cooper, for help in the construction of the map.

Western State Teachers College
Kalamazoo, Michigan

THE BEHAVIOR OF DECAPITATED SEEDLINGS *

CARL D LA RUE AND MAE MACNEILL

DURING the progress of an investigation (4, 5) of regeneration in mutilated seedlings it was found that cotyledons which had been isolated on wet filter paper expanded to a size approximately twice that of normal cotyledons attached to growing embryos This led to a test of the behavior of cotyledons on embryos which were prevented from normal growth by the removal of the plumules, from the fact that under such conditions the cotyledons became hypertrophied there arose the idea of studying the response of foliage leaves to such treatment Only later was it discovered that Wagner (7) had made extensive studies on the cotyledons of decapitated seedlings, and that Rohrer (6) had investigated both cotyledons and foliage leaves on decapitated plants

However, the studies described in this paper were extended to a number of species not used in the experiments of either Wagner or Rohrer These studies not only confirm their excellent work, but also considerably augment their results Wagner and Rohrer confined their experiments to dicotyledonous plants, but in the present work similar methods were used, with interesting results, in the investigation of several species of grasses.

EXPERIMENTS WITH DICOTYLEDONEAE

Seeds were germinated in good earth As soon as the seedlings had developed sufficiently for the cotyledons to separate well, the plumules were excised with a sharp needle scalpel Control plants were allowed to grow normally in the pots containing the subjects of the experiment

The effect of decapitation on foliage leaves was tested in the same way, except that the stems were excised above the first foliage leaf or,

* Papers from the Department of Botany of the University of Michigan, No 430.

in plants with opposite leaves, above the first pair of foliage leaves In these plants, as well as in those described in the preceding paragraph, new buds were removed as soon as they appeared

RESULTS WITH PLANTS FROM WHICH THE PLUMULES HAD BEEN EXCISED

In the experiment with plants from which the plumules had been excised the following species were used [1] **Cannabis sativa* L (hemp), *Beta vulgaris* L (beet), **Beta vulgaris* var *Cicla* L (Swiss chard), **Spinacia oleracea* L (spinach), **Silene latifolia* (Mill) Britten & Rendle (bladder campion), *Brassica alba* Rabenh (white mustard), **Brassica nigra* Koch (black mustard), **Brassica caulorapa* Pasq (kohl-rabi), **Brassica Napus* L (rape), **Brassica oleracea* var *capitata* L (cabbage), **Brassica oleracea* L var *gemmifera* Zenker (Brussels sprouts), *Raphanus sativus* L (radish), **Geum urbanum* L (avens), *Lupinus albus* L (lupine) **Robinia Pseudo-Acacia* L (black locust), **Gleditsia triacanthos* L (honey locust), *Phaseolus vulgaris* L (kidney bean), **Linum usitatissimum* L (flax), **Linum perenne* L (perennial flax), *Ricinus communis* L (castor bean), **Impatiens balsamina* L (garden balsam), **Hibiscus esculentus* L (okra), *Cynoglossum chinense* (Chinese forget-me-not), **Lycopersicon esculentum* Mill var *commune* Bailey (tomato), *Cucurbita Pepo* L (pumpkin), *Cucurbita maxima* Duchesne (squash), **Citrullus vulgaris* Schrad (watermelon), and *Helianthus annuus* L (sunflower) The nomenclature of the cultivated plants is that of Bailey (2)

In all these species the cotyledons on the decapitated plants lived longer than those on the control seedlings The life of the cotyledons of the lupine was prolonged 20 days, of the kidney bean, 21 days, of the honey locust, 25 days, of the tomato, 30 days, of the black locust, 34 days, of cabbage and kohl-rabi, 36 days, of the squash, 40 days, of okra, 90 days, and of the castor bean, 180 days All the others showed greater increases in length of life than the lupine and considerable less than the castor bean

Cotyledons on the decapitated plants almost invariably increased in size Sunflower, flax, perennial flax, bladder campion, honey locust, and Chinese forget-me-not were notable exceptions to this statement and did not reveal significant increases Black locust

[1] The species marked with an asterisk were not studied by either Wagner or Rohrer

cotyledons did not grow much beyond normal size, either, but by far the greater number of the species showed one and one-half to two times more expansion of the cotyledons than did control plants, as is indicated in Table I Petiolar length increased in about the same proportion However, the growth of these organs appeared to have a definite limit, as in normal plants, and generally ceased only a few days later than in normal seedlings

TABLE I

SIZES OF COTYLEDONS FROM NORMAL AND FROM DECAPITATED PLANTS
Measurements are in mm

Name of plant	Cotyledons from Normal Plants		Cotyledons from Decapitated Plants	
	Length	Width	Length	Width
Bladder campion	12	5	15	7
Brussels sprouts	7	8	11	12
Cabbage	19	12	38	20
Castor bean	97	60	133	72
Chinese forget-me-not	10	5	12	8
Flax	15	8	21	11
Garden balsam	25	20	43	30
Hollyhock	13	9	19	9
Honey locust	25	11	30	14
Kohl rabi	16	15	39	18
Lupine	17	19	35	20
Okra	27	25	53	33
Perennial flax	14	10	22	14
Pumpkin	72	28	110	51
Radish	38	15	72	28
Squash	70	41	103	51
Sunflower	30	16	44	21
Swiss chard	24	6	47	9
Tomato	35	8	63	11

The hypertrophy of the cotyledons on the decapitated seedlings manifested itself in increased thickness as well as in lateral expansion Nearly all cotyledons were twice as thick as usual, and some were three, or even four, times as thick They were much more turgid, too, than normal cotyledons, and soon became very brittle, so that they resembled the leaves of succulents

The color of the abnormal cotyledons, if we may call them that, was always different from that of the normal organs on the control plants They were a darker green, and this dark color persisted throughout their lives Sections showed an increase in the number of chloroplasts in their cells

The positions of the hypertrophied cotyledons were usually not those of the normal organs In all the members of the Cruciferae the behavior was the same The petioles remained straight and the blades flat, but they were turned sharply down on the hypocotyls, so that some plants showed the pairs of cotyledons crossed, one over the other Such plants resembled little manikins with hands crossed at the wrists Flax cotyledons were deflexed and flattened against the hypocotyls In radishes the petioles remained horizontal, but the blades were curved downward Spinach and Swiss chard cotyledons bent downward in sweeping curves, and those of the beet curved in the same way except that they turned upward at the tips The tomato cotyledons took positions similar to those of the beet, but the edges were turned up in an unusual way Most of the hypertrophied cotyledons tended to have their edges reflexed, although those of flax and the crucifers remained flat Pumpkin, squash, and sunflower cotyledons were curved downward sharply and often became rolled into spirals, probably indicating that the cells in the upper part of the structures had become more swollen than those of the lower regions In the garden balsam the petioles of the hypertrophied cotyledons became considerably longer than those of normal cotyledons, and instead of remaining horizontal, as normal ones do, turned almost vertically upward The blades on these vertical petioles bent strongly downward

In view of the fact that decapitated plants must have very limited powers of food production, in spite of an increased number of chloroplasts in their cells, it appears that they must rely for their growth on the food supply originally stored in them, and, since they have grown so much larger than normal cotyledons, it might be suspected that the increased size is mainly due to additional water stored in their cells Dry-weight determinations of the percentage of water in normal and hypertrophied cotyledons were made for four species, with the results given in Table II Squash and castor bean do not show so high an increase in water content as was expected However, lupine and garden balsam, whose cotyledons were more strongly hyper-

trophied than any others in the experiment, both have much more water in the abnormal than in the normal cotyledons Even so, normal as well as abnormal cotyledons contain a much lower percentage of water than do most plant organs The determinations were made after the cotyledons had grown to full size, but before they had given signs of deterioration

TABLE II

WATER CONTENT OF COTYLEDONS ON NORMAL AND ON DECAPITATED PLANTS

Plant	Percentage in cotyledons from normal plants	Percentage in cotyledons from decapitated plants
Castor bean	5 87	6 81
Garden balsam	3 74	9 15
Squash	13 44	16 23
White lupine	7 71	13 32

The cotyledons on the decapitated seedlings have been referred to as hypertrophied structures, and the question naturally arises whether they have increased their size by cell divisions Table III represents data concerning the comparative sizes of epidermal cells of normal and abnormal cotyledons of a few species

TABLE III

COMPARATIVE SIZES OF EPIDERMAL CELLS OF COTYLEDONS FROM NORMAL AND FROM DECAPITATED SEEDLINGS

Plant	Ratio of length of cells of abnormal cotyledons to length of cells of normal cotyledons	Ratio of width of cells of abnormal cotyledons to width of cells of normal cotyledons
Castor bean (lower epidermis)	0 86	0 92
Squash (lower epidermis)	1 51	1 56
Tomato (lower epidermis)	1 46	1 20
White lupine (upper epidermis)	1 27	1 35

Microtome sections were made of normal and abnormal cotyledons of balsam, black locust, bladder campion, cabbage, castor bean, Chinese forget-me-not, flax, honey locust, kidney bean, kohl-

rabi, lupine, okra, squash, sunflower, and tomato in order that the changes in the internal structure might be determined In some of these fixation was poor, for it appears that it is more difficult to secure good fixation in cotyledonary tissue than in tissue of foliage leaves Bouin's fluid and Zenker's solution proved the best of the different fixatives tested

All the cells of the cotyledons mentioned had become larger than the normal cells Chloroplasts were more abundant in all the hypertrophied cotyledons The epidermal cells were thicker in all the abnormal cotyledons Okra and castor bean cotyledons were the only ones which had a structure like that of foliage leaves These belonged to the group referred to by Godfrin (3) as "foliaceous" cotyledons and had a definite palisade layer, which was made up of longer and larger cells in the abnormal cotyledons The spongy layer was thicker also than in the normal ones Table III shows that the epidermal cells of the castor bean divide, but that internally its greater growth is caused by cell hypertrophy The abnormal cotyledons of the honey locust were the only ones which had an abundance of stored starch, which was lacking in the normal structures The abnormal tissues were vastly better supplied with chloroplasts than the normal

In a few species comparisons were made of the sizes of vein islets in normal cotyledons and in those from decapitated plants The results, which agree essentially with those gained from the study of the epidermal cells, are shown in Table IV

TABLE IV

Comparative Sizes of Vein Islets from Normal and Decapitated Seedlings

Plant	Ratio of length of islets of abnormal cotyledons to length of islets of normal cotyledons	Ratio of width of islets of abnormal cotyledons to width of islets of normal cotyledons
Balsam	1 46	1 44
Kohl-rabi	2 11	2 40
Okra	3 11	3 05
Sunflower	1 34	1 29
Tomato	1 81	1 35

In the majority of species the hypocotyls of the decapitated plants were modified to only a slight extent The kidney bean

hypocotyls became elongated very noticeably, and took on a much greener hue. The abnormal hypocotyl was nearly twice as large in diameter as the normal, and the cortical cells showed great increases in size. However, the hypocotyl of the decapitated plant had scarcely any mature vessels in the xylem, and the few which were present were much smaller than those of the normal structure. Wagner's studies (9) of several other species gave similar results. Lupine and okra hypocotyls were elongated, but much less so than those of the bean. Tomato hypocotyls were far slower in developing the purple coloration than were the normal ones, and the green color was also more pronounced. The hypocotyls of the cruciferous plants differed scarcely at all from those of ordinary seedlings. Possibly they were a little greener, but they were not at all hypertrophied.

New buds always appeared within a few days after decapitation. If allowed to grow these soon developed into ordinary shoots, although usually the first two or three leaves were abnormal in shape. Aside from a few plants on which adventitious buds were allowed to grow in order to determine the nature of their development, the decapitated plants were kept free from adventitious buds. In most species new buds usually appeared first in the axils of the cotyledons, even in plants where there seemed to be no axillary buds. In work on the regeneration of cotyledons (5) it was found that many cotyledons were capable of producing shoots, although, apparently, there were no buds on them. Actually nearly all had small buried buds on them when they emerged from the seed. These small buds are the ones which first develop after decapitation has been performed. When they are removed adventitious buds replace them, often in the axils of the cotyledons, but in many instances on the cut end of the stem above the cotyledons. In the radish, bud production is abundant, and the buds arise not only in the axils, but also at the sides of the cotyledons and on the cut ends of the stems as well.

In the crucifers the adventitious buds were most frequent on the cut stumps, but in cabbage and Brussels sprouts they arose in the axils of the cotyledons also. In another way these two varieties were different from any others observed in this experiment; they produced buds at the root crown, or just below it, for the buds arose below the surface of the soil. So far as the writers are aware, such production of buds has not been reported before, although it is well

known that some plants readily form buds on their hypocotyls Flax did so in the present experiment

Beet, Swiss chard, and tomato form new buds more quickly and abundantly than do any other plants observed In addition to putting out shoots from the axils of the cotyledons and around the edges of the cut stumps of the stems, they regularly produce pads of tissue on the cut ends of the stems, which become entirely covered with little buds As soon as the buds are removed they are replaced by others, so that in the course of two months of life one plant may form as many as thirty or forty buds In sharp contrast to such plants the sunflower and the castor bean develop only one or two buds in the axil of each cotyledon, and then appear to have exhausted their resources for regeneration.

Quite by accident it was learned that the cotyledons of decapitated plants are much more resistant to cold than are normal cotyledons One winter night a window of the greenhouse near the experimental plants was left ajar The next morning all the plants seemed free from injury, and certainly none had been frosted The following day, however, the cotyledons on the normal seedlings began to droop, and within another day or two all had withered and fallen The cotyledons on the decapitated plants showed no sign of any injury, and thereafter lived out their usual span of existence None of the foliage leaves on the control plants gave any indication of injury from frost There was no doubt that the low temperature was the cause of the premature death of the normal cotyledons, for ordinarily all would not have died at the same time Since the cotyledons on decapitated plants cannot use up their reserve food in growth to the same degree that normal cotyledons do, they may contain a greater amount of sugar, or other solutes, which protect them against injury by cold

The roots of the decapitated plants were of very small extent in all species They were often not more than one fourth as numerous, or as large, as those of normal seedlings of the same age Commonly they were limited to a thin, short taproot and a small number of secondary roots The question whether or not the roots limit the growths of the cotyledons will be discussed later

RESULTS WITH PLANTS FROM WHICH THE STEM HAD BEEN REMOVED ABOVE THE FIRST FOLIAGE LEAF

In the experiment with plants from which the stems had been removed above the first foliage leaves the following species were used [1] **Cannabis sativa* L (hemp), **Beta vulgaris* L (beet), **Beta vulgaris* var *Cicla* L (Swiss chard), **Spinacia oleracea* L (spinach), *Brassica alba* Rabenh (white mustard), **Brassica nigra* Koch (black mustard), **Brassica caulorapa* Pasq (kohl-rabi), **Brassica Napus* L (rape), **Brassica oleracea* var *capitata* L (cabbage), **Brassica oleracea* L var *gemmifera* Zenker (Brussels sprouts), *Raphanus sativus* L (radish), *Lupinus albus* L (lupine), **Linum usitatissimum* L (flax), **Impatiens balsamina* L (garden balsam), **Lycopersicon esculentum* Mill var *commune* Bailey (tomato), *Cucurbita maxima* Duchesne (squash), and *Helianthus annuus* L (sunflower)

The cotyledons on these plants developed in all respects exactly as did those on plants which had been deprived of their plumules They lived as long on these plants as on decapitated plants, but no longer, so that, finally, these plants came to be made up of root, hypocotyl, and a single leaf

Conversely, it did not appear that the cotyledons exercised any influence on the growth of the isolated foliage leaves, for those leaves did not vary, regardless of whether the cotyledons were left attached for their entire lives or removed as soon as the foliage leaves had reached full size If the cotyledons were removed as soon as the foliage leaves had unfolded, the growth of these leaves was greatly retarded, obviously by lack of food, but otherwise they were not influenced

The hypocotyls, also, were not distinguishable from those of plants decapitated at the base of the first internode of the stem They did not become longer or larger in diameter

New buds grew on plants with a single foliage leaf, as on those with none, and in corresponding locations Buds developed in the axils of the first foliage leaves, usually before those in the axils of the cotyledons In some species, the hemp, for example, development of the buds in the axils of the cotyledons was long delayed Here the foliage leaf evidently had the effect of suppressing the

[1] Names of species marked with an asterisk were not studied by Rohrer

lower buds In cabbage, kohl-rabi, and Brussels sprouts this dominance was not great enough to prevent formation of buds at the root crown, though it did serve to delay the appearance of the axillary buds of the cotyledons In all species buds developed in the axils of the foliage leaves, and in most of them the cut ends of the stems produced buds Hemp, sunflower, and balsam did not develop any buds on the cut stem end, and tomato, beet, and Swiss chard threw far fewer than were formed on the stem ends of plants decapitated above the cotyledons When new buds were allowed to grow into shoots the life of the isolated foliage leaves was greatly shortened

The isolated first leaves, or first pairs of leaves in plants with opposite leaves, usually outlived the cotyledons below them, and also outlived the first leaves on control plants Usually their lives were doubled or even quadrupled by their isolation

The most striking difference between the isolated first leaves and normal ones is in size Generally the isolated leaves are about twice as large as the normal ones (See Table V)

TABLE V

Comparative Size of Isolated First Leaves and of First Leaves of Normal Plants

Plant	Ratio of blade length of isolated leaves to blade length of normal leaves	Ratio of blade width of isolated leaves to blade width of normal leaves	Ratio of petiole length of isolated leaves to petiole length of normal leaves
Balsam	2 21	2 10	
Beet	2 35	2 94	2 33
Black mustard	1 72	1 64	3 00
Brussels sprouts	1 66	2 23	1 20
Cabbage	2 67	2 43	2 53
Hemp	1 70	1 50	3 33
Kohl-rabi	1 86	1 75	1 32
Radish	2 00	2 20	1 63
Rape	1 50	1 90	1 20
Spinach	1 53	2 33	1 66
Sunflower	2 06	1 24	2 50
Swiss chard	2 67	3 20	3 30
Tomato	2 02	2 15	2 09
White mustard	1 98	2 38	2 42

The increased expansion of the laminae of the isolated leaves was accompanied by an increase of from two to four times in thickness The hypertrophied leaves were much more succulent, more turgid and rigid, also much more brittle

If the normal leaves were toothed the teeth were very likely to be less pronounced on the isolated leaves Lobing was usually reduced Normal first leaves of black mustard showed five lobes and the hypertrophied ones three, normal leaves of tomato, four lobes, the isolated ones, three

Unusual tensions were evident in the hypertrophied leaves, which were seldom flat, but commonly curved In tomato they were bent backward toward the tip, but more of the species showed curving of the edges than of the midribs The upper surfaces are strongly convex in sunflower, spinach, cabbage, rape, balsam, and squash Brussels sprouts and kohl-rabi revealed slight concavity of the upper surfaces, and radish, beet, and Swiss chard leaves were usually so much curved upward at the edges as to make these edges touch or even overlap one another

The petioles of the solitary first leaves are not notably different from normal ones except in their greater length and diameter Several of them were sectioned and found to contain more and larger xylem elements than normal petioles, and parenchyma cells twice as large as the normal ones The petioles are disproportionately expanded at the base and usually almost completely surround the stem They also take a peculiar position and appear terminal rather than lateral in most species, with the cut ends of the stems sunken into their bases

The stems of these plants consist of the hypocotyl and the first internode above the cotyledons The hypocotyls have been discussed, and the first internodes may be dismissed with mention of the fact that they are usually much shortened, often to a half or a third of the normal length They do not continue to grow in diameter in a normal way, but develop little beyond the size attained by normal stems in early seedling stages In some species they showed a heightened green tint, but not in others

In root development the plants with a single foliage leaf were intermediate between normal plants and those decapitated just above the cotyledons

The size of cells in isolated foliage leaves was studied principally

by making drawings, with the aid of a projection apparatus, of the cells of the upper and the lower epidermis. The results are given in Table VI As they stand, the data are suggestive rather than mathematically accurate because the number of cells measured was usually not more than twenty for a given sample, and the irregularity of epidermal cells is such as to make it difficult to measure them accurately However, there was no possibility of doubt that the epidermal cells of the decapitated plants of most species were about twice as large as cells of the same type from normal first leaves This indicates clearly that the increases in leaf size have been made by hypertrophy of the cells rather than by cell divisions Hemp is the only species investigated in which it appears that the growth of the abnormal leaves is due to an augmented number of cell divisions

TABLE VI

SIZES OF EPIDERMAL CELLS OF ISOLATED FIRST LEAVES COMPARED WITH THOSE OF EPIDERMAL CELLS OF NORMAL FIRST LEAVES

Plant	Upper Epidermis		Lower Epidermis	
	Ratio of length cells of isolated leaves to length cells of normal leaves	Ratio of width cells of isolated leaves to width cells of normal leaves	Ratio of length cells of isolated leaves to length cells of normal leaves	Ratio of width cells of isolated leaves to width cells of normal leaves
Balsam	2 15	2 55	1 49	1 32
Beet	2 18	1 80	2 20	1 65
Black mustard	1 70	1 30	1 54	1 72
Brussels sprouts	1 36	1 52	1 31	1 74
Cabbage	1 57	1 16	1 76	1 87
Hemp	0 65	0 96	0 83	0 92
Kohl-rabi	1 96	2 39	1 65	1 54
Radish	2 08	1 44	1 98	1 35
Spinach	1 34	1 17	1 70	1 94
Sunflower	1 87	1 74	1 94	1 65
Swiss chard	1 92	2 44	1 29	1 47
Tomato	1 72	1 74	1 61	1 38
White mustard	2 08	2 24	1 60	1 87

The internal tissues of the isolated leaves were studied in cabbage, kohl-rabi, Swiss chard, and tomato Free-hand sections were

made of these and also of normal first leaves from control plants of the same species In cabbage the isolated leaves were approximately twice as thick as the control leaves, but did not differ in structure Chloroplasts and starch grains were much more numerous in the isolated leaves than in the controls In kohl-rabi the abnormal leaves were just twice as thick as the normal ones Chloroplasts and starch grains were more numerous Results with tomato and Swiss chard were essentially the same In the latter both normal and abnormal leaves had chloroplasts in the upper and lower epidermis, but in the control leaves they were very few

EXPERIMENTS WITH MONOCOTYLEDONEAE

In the experiment with monocotyledonous plants the following species were used *Holcus sudanensis* Bailey (Sudan grass), *Hordeum vulgare* L (barley), *Triticum sativum* Lam (wheat), and *Zea Mays* L var *"Pride of the North"* (corn)

The outcome of experiments in which seedlings of grasses were decapitated immediately above the cotyledons has been related in a previous paper (6) We deal here with the results of decapitation above the coleoptilar node, above the second node, and above the third node

Two methods of decapitation above the coleoptilar node were used in all the species except maize The first method involved the clipping of the shoots even with the tip of the coleoptiles, thus performing a decapitation not quite at the base of the internode, but very near it The other treatment consisted of pulling the shoots out of the coleoptile as soon as they projected sufficiently Both methods had the disadvantage of requiring almost daily treatment over a period of several days The shoots which were clipped were pushed up by basal growth more rapidly than those which had been torn out from the coleoptiles, but in both sets there was a surprising amount of new growth Barley seedlings manifested much more vigorous growth than wheat or Sudan grass

So far as wheat, barley, and Sudan grass were concerned, decapitation was without effect on the coleoptiles They did not grow larger or live longer than in normal plants

In corn seedlings the technique was altered slightly Because the plants were larger it was possible to open the coleoptiles and cut the shoots out at the base of the internodes immediately above the

coleoptilar nodes This was not often done without some damage to the coleoptiles, but the injuries were not very serious and the coleoptiles remained alive and turgid On most of the experimental seedlings the only result that could be seen was that the coleoptiles were definitely plumper and more turgid than the ones on control plants

Another set of seedlings, from sterilized seeds, was grown on damp filter paper in Petri dishes instead of being planted in the earth As soon as the shoots emerged from the coleoptiles they were pulled out with the fingers without any injury to the coleoptiles Thereafter new growths were removed in the same way as soon as they appeared All the coleoptiles on these plants became slightly larger than those on control plants in the same dishes What is more interesting is the fact that, out of a lot of twenty seedlings *from which the shoots had been removed, four produced coleoptiles* which bore definite and distinct blades with ligules at their bases One was very leaflike the other three were rather slender In a recent paper Avery (1) states that one of the reasons for thinking the coleoptile is not the first foliage leaf of the grass seedling is the failure of the organ to develop a leaf blade It seems that under certain circumstances the coleoptile of the corn seedling has the ability to develop a blade

Tests were made of the effect of allowing the first regular foliage leaf in corn, wheat, and barley seedlings to develop In one set the shoots were pulled out of the sheaths of these leaves, and in another they were clipped off at the tops of the sheaths The results showed no marked differences In no case did the isolated leaves grow larger than the normal ones, nor were they different in appearance in any other way However, the isolated leaves invariably lived longer than the normal ones In corn seedlings they outlived the first, second, and sometimes the third leaves of control seedlings In wheat they lived longer than the first, second, third, and sometimes the fourth leaves of normal plants In barley the isolated seedlings were less altered, and although they outlived the first leaves of control seedlings they did not always live longer than the normal second leaves

In corn seedlings alone the experiment was made of removing the shoots above the second regular foliage leaves, so that the plants bore the coleoptile and first and second foliage leaves The

coleoptile and first leaf behaved as they did when the second leaf was absent The second leaf was wider and longer than a normal leaf by about one third In most instances it lived as long as the normal fourth leaf on the control plants

The root condition of decapitated grass seedlings was much the same as in dicotyledonous plants The roots of the barley seedlings with only one foliage leaf were very few and weak In wheat seedlings with only one foliage leaf the first internode, that between the scutellar node and the coleoptilar node, was little different from the normal forms However, the normal seedlings had many more roots below the cotyledons At the coleoptilar node the decapitated seedlings produced, if any at all, only one or two small adventitious roots Normal plants formed from three to six large adventitious roots at this node

In corn, seedlings which were allowed to develop two foliage leaves formed a root system approximately one half as large as that of normal plants of the same age (fifty-seven days) Seedlings with only the first foliage leaf intact had about one fourth as large a root system as control plants They averaged five small adventitious roots from the coleoptilar node, seedlings with two foliage leaves averaged eight adventitious roots, and control plants averaged fourteen roots from this node The ratio of roots to tops, then, was about the same as in dicotyledonous seedlings

DISCUSSION

The augmented size of cotyledons on plants which have been decapitated has been noted by both Wagner (9) and Rohrer (8) In the present paper data are given for seventeen species other than those studied by Wagner and Rohrer, and the behavior of these additional species agrees with that of the plants observed by these workers

Godfrin (3) found that the cotyledons which he classes as "tuberculous" had as many cells when in the seed as when they were fully developed on the germinating seedling, but he found that another class of cotyledons existed, which he called "foliaceous" and which were enlarged by cell multiplication It might appear that cotyledons of this type could grow indefinitely by continued cell division, but such is not the case It is very likely that such cotyledons are limited in their cell divisions in the same way as foliage leaves are

Most of the isolated foliage leaves are restricted in their growth by the extent of the hypertrophy of their cells Hemp may be an example of a plant in which the isolated leaves grow by an increased number of cell divisions, but there is just as definite a termination of the growth of isolated hemp leaves as in any others The conditions appear to be quite the same whether the isolated organs are cotyledons or foliage leaves There is no evidence, however, as Wagner has pointed out, that the cotyledons are merely inhibited foliage leaves

The increased length of life of isolated cotyledons may be due to their position, since they have no leaves above them to remove water from their tissues As yet we do not have data on the comparative transpiration rates of cotyledons and foliage leaves for these plants Neither do we know whether the life of leaves would be prolonged by removing the stem and upper leaves after they have reached maturity When we have such data at hand we may be better able to determine to what extent water supply is concerned with increased longevity in isolated leaves

Monocotyledonous seedlings, when decapitated, seem to have a curious mixture of the reactions seen in dicotyledonous plants For instance, the life of the coleoptiles is not increased by decapitation, but in maize, at least, some of the coleoptiles are increased in size and changed in form Again, isolated first leaves have longer lives than normal ones, but do not increase in size Isolation of the second foliage leaf leads to an increase in its length of life, but apparently a little less than that of the isolated first leaf It also causes an increase in size, and one somewhat less than is common in dicotyledonous seedlings

The development of leaf blades on the coleoptiles of corn seedlings is a matter of great interest because of the light which it sheds on the nature of the coleoptile in the grasses The failure of this organ to develop any sign of leaf blade, however primitive, has led morphologists to doubt that the coleoptile represented the first foliage leaf of the grass seedling This caused them to ally the coleoptile with the scutellum as a part of the cotyledon, and led them into difficulties with the internode between the scutellum and the cotyledon. The present paper is not the place for an extended discussion of the morphology of the grass seedling, but the leaf blades induced on coleoptiles by decapitation make it almost certain that the coleoptile is the first foliage leaf, and that the interpretation of the grass

seedling given by Avery (1) is essentially correct It is hoped that decapitation and induced hypertrophy may be of further service to morphologists

The roots of the decapitated plants show interesting variations from normality Those on plants decapitated above the cotyledons were only about one half as extensive as those on seedlings decapitated above the first foliage leaf, and these in turn were only approximately one half as great in extent as those of normal plants These results hold as well for monocotyledonous as for dicotyledonous seedlings

Wagner studied the roots of seedlings from which the plumules had been removed and found that they revealed extensive development However, he did not have an opportunity to compare them with roots of plants decapitated at higher levels of the stem Rohrer removed the shoots from seedlings at various levels, above the first leaf, above the second leaf, and so on up to the fourth leaf, but he did not make any observations on root conditions Wagner believes that the roots on the decapitated plants grow normally at first, and that later, when the food supply becomes inadequate, they decline and quickly go to pieces So far as the writers' experiment shows, the conditions are not as stated by Wagner, for no indication of degeneration or decay was seen in any of the roots, yet the differences in extent were obvious The results indicate that the development was differential from the beginning, and that the top growth in some way conditioned the extent of the root development The method of decapitation may be used to advantage to extend our knowledge of the inter-relation of root and shoot growth and development

SUMMARY

1 In dicotyledonous seedlings from which the plumules have been removed the cotyledons become greatly enlarged They also become greener, thicker, and more turgid

2 In most species the epidermal cells, the mesophyll cells, and the vein islets of cotyledons on the decapitated plants are enlarged in about the same degree as the external dimensions The cotyledons are to be regarded, therefore, as hypertrophied structures

3 The hypocotyls of decapitated plants are limited in growth, but in some species become longer than those of normal seedlings

In certain species they show hypertrophies similar to but less extensive than that of the cotyledons

4 In dicotyledonous seedlings which have been decapitated above the first foliage leaf the development of the cotyledons is exactly like that on plants decapitated immediately above the cotyledons The first foliage leaves of these plants are usually about double the size of normal first leaves

5 The isolated first leaves are more turgid, and are greener than normal leaves and, usually, are about twice as thick In most of them the epidermal cells and the mesophyll cells alike show marked hypertrophy The vein islets are larger than those in normal leaves of a like age

6 The life of both cotyledons and isolated foliage leaves on decapitated plants is greatly increased over that of normal organs of the same type

7 In seedlings of grasses which were decapitated at the coleoptilar node the coleoptiles did not live longer than those of control plants, nor did they become larger in most of the species In maize, however, some of the coleoptiles developed definite leaf blades and ligules, thereby contributing important evidence that the coleoptile is the first foliage leaf of the grasses

8 Seedlings of maize decapitated above the first regular foliage leaf showed a decided increase in length of life of this leaf, but no increase in size or change of form

9 Maize seedlings decapitated above the second foliage leaf had an increase in life span of this leaf, as well as an increase in length and width

10 In both monocotyledonous and dicotyledonous seedlings which have suffered decapitation the development of the roots is proportional to the amount of top allowed to develop Decapitation seems to offer a useful method of studying the relation between root and top

University of Michigan

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A CULTURAL AND TAXONOMIC STUDY OF *HYSTERIUM HYALINUM* *

MARION L LOHMAN

IN THE taxonomy of the Hysteriaceae considerable uncertainty has become associated with the name *Hysterium hyalinum* Cooke & Peck Though some writers have placed the name in synonymy, others have retained it, but marked the species as a doubtful one The misunderstanding has been due largely to an illustration (3, Pl 81, Fig 5) of material presumably authentic for the species, but incorrectly determined and obviously not in agreement with the type specimen The present paper gives a revised description for this species and records for the first time the features of its pycnidial and hyphomycetous stages [1] The notes are based upon a study of specimens from the original collection by Peck and of identical material (occurring on decorticated weathered wood, possibly Populus) collected by the writer at Petersham, Massachusetts, in October, 1931 [2]

The fungus which Cooke described (2) in 1875 as *Hysterium hyalinum* Cooke & Peck, with hyaline, cross-septate ascospores, was collected by Peck in New York Having been described as a hyaline spored form, it was listed subsequently by Saccardo (*Sylloge*, 2) as *Gloniella hyalina* (C & P) Sacc Since that time no fungi have been reported for North America under the latter name, although several records of *Hysterium hyalinum* are to be found They are New Jersey, by Cooke and Ellis (3) in 1876, Louisiana, by Langlois (7) in 1887, New Jersey, again, by Ellis and Gerard (6) in 1889 Identifications in these records have not been verified, since

* Contribution No 121 from the Laboratories of Cryptogamic Botany, Harvard University

[1] The work here reported was made in conjunction with other studies by the writer during the tenure of a National Research Council Fellowship 1931-33 under the sponsorship of Professor William H Weston Jr

[2] The writer is indebted to Miss E M Wakefield, of the Royal Botanical Garden at Kew, for a loan of the type material of this species

the collections upon which they are based were not seen in connection with this study. The first, however, undoubtedly refers to a fungus with hyaline, muriform spores (3, p. 54, Pl. 81, Fig. 5, 4, p. 708, 1, p. 313) and represents the collection upon which Ellis placed *Hysterium hyalinum* in the synonymy of *Hysterographium gloniopsis* (Ger.) E. & E. (4), a fungus known also as *Gloniopsis Gerardiana* Sacc.

The point to be gained, then, from this historical sketch is that the name *Hysterium hyalinum* stands for a fungus with cross-septate spores which remain hyaline for some time, but, according to the observations of both Bisby and the writer, finally become brown, whereas the names *Hysterographium gloniopsis* and *Gloniopsis Gerardiana* designate a fungus with muriform spores which remain hyaline.

In discussing the type specimen of *Hysterium hyalinum*, Bisby stated: "It does not look like *Hysterium pulicare*, it may indeed be young *Hysterographium Mori* as Peck intimates." In his summary he included *H. hyalinum* Cooke & Peck among names which still remain doubtful. It occurred to the writer that an examination of the type material with respect to a possible associated pycnidial stage might offer a basis for either the complete rejection or the validation of this name, especially since he (9) had demonstrated a pycnidial stage of one type for *Hysterium pulicare* and *H. insidens* and of another type for *Hysterographium Mori* and *Gloniopsis Gerardiana*. Such a study was made, and the pycnidial stage present proved to be one of the Hysterium type. Besides, hysterothecia examined showed ascospores of the Hysterium type (Fig. 3 *A*, *B*).

THE HYSTEROTHECIAL STAGE OF THE FUNGUS

The ascigerous fructifications are typically hysteriaceous, i.e. they are elongate with a central narrow fissure, black, carbonaceous, and remain closed when wet (Fig. 3 *C*, Pl. XIII).[3] With respect to size, form, surface features, thickness of the wall, and general habit, those of the collection from which the species was isolated are identical with those of the type, even to the extent of appearing immature. However, mature asci and spores were found in each

[3] The prominent transverse cracks in certain hysterothecia of the photomicrograph are mere breaks. They are not uncommon in weathered specimens of the Hysteriaceae and probably result from tensions produced by the periodic swelling and shrinking of the wood.

The asci of the species have no features of particular diagnostic value (Fig 3 *A*) Their measurements in the type collection — these were not given by Cooke — are 75–95 × 15 μ in the Massachusetts collection, 95 110 × 15 μ The obvious discrepancy is not

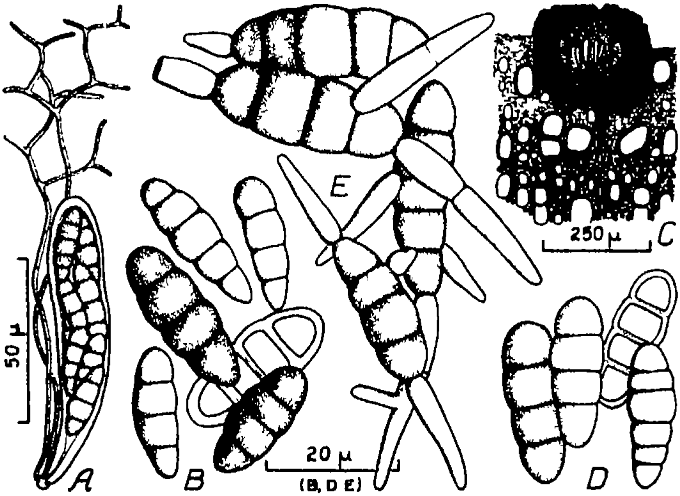

Fig 3 Illustrating especially the hyaline to brown ascospores of *Hysterium hyalinum* *A B* from the type collection Peck 47 (New York), *C–E* from living material (Massachusetts) The drawings were outlined with the aid of the camera lucida As they are reproduced the approximate magnifications are *A*, × 500, *B*, *D–E* × 1000, *C* × 65

a serious matter in view of the variation commonly encountered in the Hysteriaceae

The ascospores (Fig 3 *B*, *D*) of the fungus are largely as Cooke described them (2) They do, however, become pale brown when matured, also, occasionally, they are 4- or 5-septate In this species apparently any cell of a viable spore is a potential germ cell (Fig 3 *E*)

THE CULTIVATION OF THE FUNGUS

In the isolation of the fungus from the collection of 1931 only the yellowish to brown spores were found to germinate, and germination of such spores was obtained only after they had been sub-

jected to outdoor weathering for eight weeks in the winter season In the cultural study the organism was grown on a maltose and malt extract medium (8, p 147) and on oat agar, in diffused daylight at 20–25° C

Although much slower in growth, the developing mycelia of this species resemble those of *Hysterium pulicare* in that smooth, dark, surface mats are produced without cottony aerial wefts, and in that various cells of the hyphae become pyriform or globular, thick-walled, brown, and store oil In cultures on either medium a conidial stage of the form genus Sporidesmium was produced by the end of the third month, more abundantly, however, on the maltose medium than on the oat agar Pycnidia were not formed in these cultures even after they had run for six months

THE SPORIDESMIUM STAGE OF THE FUNGUS

The conidia as produced in culture are dark brown to opaque, constricted at the septa, granular-incrusted and measure 12–22 ×

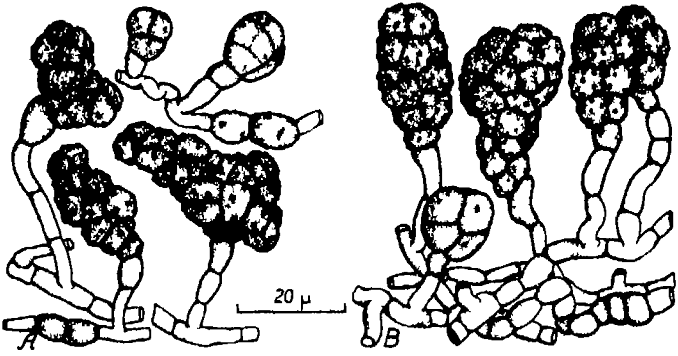

FIG 4 Illustrating the Sporidesmium stage of *Hysterium hyalinum*, cultured from a collection made at Petersham, Massachusetts *A*, conidia from ascosporous cultures, *B* conidia associated with the hysterothecial stage in the field collection The drawings were outlined with the aid of the camera lucida As reproduced they represent a magnification of about × 825

12–16 (20) μ (Fig 4 *A*) Each conidium arises by the septation of a globose cell, borne on the end of a slender, one- or several-celled conidiophore The multicellular condition is attained by the growth and septation of the peripheral cells Through unequal growth

variously distorted conidia obtain When one considers the fact that the conditions affecting growth in laboratory cultures tend to produce such abnormalities in conidia of this type, the conidial stage obtained agrees very well with that associated with the hysterothecial stage in the field material

The conidia in the field material are quite regular in form but show a considerable range in size (Fig 4 *B*) They measure (12) 15–20 (25) × (8) 10–16 (18) μ Occurring on the wood in compact, elliptic-linear, scattered sori which range from 150 to 450 μ in length, they are noticeable to the unaided eye only as blackened areas bordering the aggregations of hysterothecia

The identity of this conidial stage as a form species cannot be determined with satisfaction at the present time It is highly probable that the stage has been described as a Sporidesmium, for no fewer than fifteen such form species, very inadequately described in the earlier literature, are based upon specimens collected upon weathered wood of deciduous species in the temperate area east of the Rocky Mountains The described forms which are more or less similar to this stage and apparently not readily separable — forms which differ among themselves mainly with respect to such features as the presence or persistency of the conidiophore, the translucent or opaque condition and the rounded or angular form of the cells, the smooth or granular-incrusted condition of the wall, all of which without doubt are variable characteristics — include such names as *Sporidesmium acinosum* B & C , *S fumosum* E & E , *S hysterioides* C & E , *S microsporum* Ellis & Barth , *S minutissimum* Peck, and *S velutinum* Cooke Disposition of the conidial stage of *Hysterium hyalinum* in a satisfactory manner requires a critical comparative study of the type materials of the species mentioned Therefore, at present, it appears to be desirable simply to describe the stage in connection with the revised description of the species

DIAGNOSIS AND POSSIBLE AFFINITY OF THE SPECIES

That a more adequate conception of the species may be available, the following description is based upon both the type material and the recent collection by the writer [4]

[4] For a satisfactory diagnosis of the type only the facts that the asci measure 75–95 × 15 μ and that the ascospores become brown need be added to Cooke's original description

Hysterothecia loosely aggregated and forming cinereous patches on the weathered wood, black and carbonaceous, 1.5–2 or as much as 2.5 mm. long, 0.25–0.35 mm. broad, erumpently superficial with the ends rounded when exposed, minutely rugose-punctate and occasionally faintly longitudinally striate, thick-walled, either the basal or lateral wall measuring up to 85 μ, with the longitudinal furrow prominent; *asci* cylindric-clavate, (75) 85–110 × 15 μ, paraphysate with the paraphyses branched and interwoven above; *ascospores* irregularly biseriate, fusiform, hyaline to pale brown, 20–26 (28) × 6–8.5 μ, mostly 3- but occasionally 4- or 5-septate, constricted at the septa when mature.

Pycnidia (known only as an associated stage in the type collection; except for their larger size, identical with the pycnidial stage of *Hysterium insidens* Schw., cf. 9, pp. 262–266) superficial, black, membranous and fragile, attenuate-globular and ostiolate, 75–95 μ in diameter and 95–125 μ in height, the lateral walls 8–12 μ thick; *pycnidiospores* hyaline, cylindric-inequilateral, 3–4.5 × 0.7–1 μ, produced acrogenously on slender, bent sporulating cells which form a palisade lining the lateral and basal walls of the pycnidium.

Conidia (Sporidesmium) either scattered or in compact, elliptic-linear sori 150–450 μ long bordering the aggregations of hysterothecia, deep brown to opaque, (12) 15–20 (25) × (8) 10–16 (18) μ, multicellular and granular-incrusted, subglobose or clavate-swollen and broadly rounded above, occasionally subcatenulate, produced on short, slender, yellowish, one- to several-celled conidiophores.

In view of the present study and published notes (9) concerning the pycnidia of *Hysterium pulicare* Pers. ex Fr., *H. insidens* Schw., *Hysterographium Mori* (Schw.) Rehm, and *Gloniopsis Gerardiana* Sacc., certain conclusions concerning the probable affinity of this species may be drawn. On the basis of the pycnidial stage present in the type material of the species *H. hyalinum* appears to be closely related to *H. pulicare* and *H. insidens*, resembling the former with respect to cultural habit and the features of the mature hymenial elements, but resembling the latter with respect to general habit and the features of the pycnidial stage. *Hysterographium Mori* and *Gloniopsis Gerardiana*, closely related species with a different pycnidial stage, appear, then, to have no close relationship with this species.

When original descriptions alone are considered, *Glonîella ambigua* Karst. appears to be the European counterpart of *Hysterium hyalinum*

SUMMARY

A cultural study has been made of *Hysterium hyalinum* Cooke & Peck, the species was isolated from material collected in 1931 near Petersham, Massachusetts In verifying the identification a portion of Peck's original collection of the species was examined The results of the cultural and taxonomic studies and the significance of each may be briefly summarized as follows

1 The fungus collected in Massachusetts was found to agree with the type of *H hyalinum* with respect to all of the important features of the hysterothecial stage The writer has referred it to this species despite the facts that it lacks the pycnidial stage associated with the hysterothecia in the type material and that it has in association, instead, a hyphomycetous stage of the Sporidesmium type

2 The Sporidesmium stage was obtained in ascosporous cultures of the fungus on laboratory media

3 The pycnidial stage in the type material of *H hyalinum* agrees, except for its larger pycnidia, with that of *H insidens*

4 In consideration of the features of the ascospore and of the pycnidium in the type material alone, the writer suggests that *H hyalinum* be accepted as a valid name and that it be removed from the synonymy of *Hysterographium gloniopsis* (Ger) F & E listed by Ellis (4)

5 No connection between the form genus Sporidesmium and species of Hysterium has heretofore been demonstrated, or suggested

6 The need of critical systematic studies within the group of saprophytic dematiaceous Fungi Imperfecti to facilitate investigations of this kind in the Pyrenomycetes is clearly shown by this study

HARVARD UNIVERSITY

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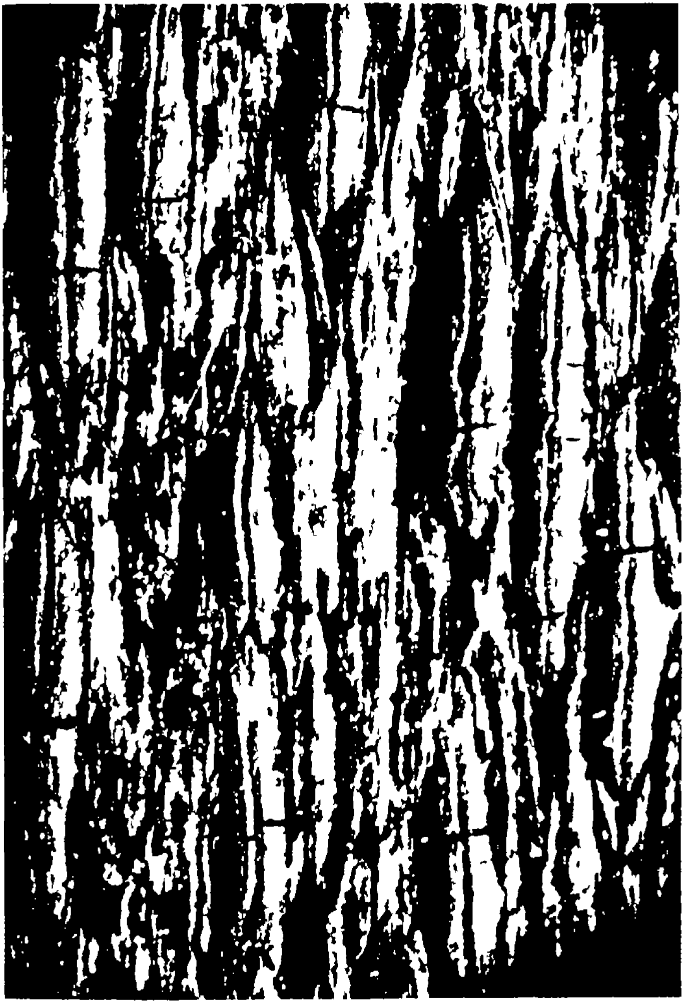
PLATE XIII



Hysterium hyalinum Cooke & Peck. Collected by M. E. Lohman near Petersham, Massachusetts, October 1931. About × 15

NOTES ON SOME SPECIES OF POLYPORUS *

JOSIAH L LOWE

THE following remarks are based for the most part upon studies of types or other critically determined specimens of certain of the rarer and imperfectly understood species of Polyporus Especial attention has been given to their relationships For convenience the species are arranged in alphabetical order

Polyporus albidus (Schaeff) Fries

(Plate XIV, Figs 1–3)

Romell's interpretation of *Polyporus albidus* (Schaeff) Fries, as published (14, pp 2–5), and as represented by specimens deposited by Romell in the Farlow Herbarium at Harvard University, is accepted as the more probable one The species has not been known under this name by American mycologists, Peck (13, p 91) described it under the name of *P epileucus* var *candidus*, and most of his specimens under the name *P epileucus* should also be referred here When dry the surface of the pileus is friable and rubs off like chalk, this character is the most striking feature of the American form of the species This species has been found only on hemlock wood *Polyporus immitis* Peck is very closely related, but occurs on wood of deciduous trees, and the surface of the pileus usually dries rough and tuberculose, sometimes subpelliculose, never, apparently, friable and chalklike Since the microscopic characters of the two species are very similar, it may well be questioned whether the difference noted is not due to the kind of substratum Until a much larger number of specimens are available for comparison, it seems better to consider these two species distinct

Polyporus amygdalinus Berk & Rav

The identity of *Polyporus amygdalinus* Berk & Rav , described by Berkeley and Ravenel (1, p 49), was uncertain until it was rede-

* Papers from the Department of Botany and the Herbarium of the University of Michigan No 426

fined by Lloyd (4, p 9) Since Lloyd's description is rather short, it seems desirable to give a lengthier one of a specimen examined in the herbarium of the New York Botanical Garden, collected in Alabama by R P Burke and probably a part of the collection reported by Lloyd For the sake of completeness the descriptions of some characters of the fresh specimens are taken from Lloyd's scattered notes on this species Such characters are indicated by the letter (L)

Pileus sessile rigid when dry, subimbricate or solitary, dimidiate, 5 10 cm wide, 0 8–2 cm thick, surface pale yellowish or orange (L), becoming brownish on drying, with darker brownish innate fibrils, sometimes with small subtomentose patches, uneven, somewhat ridged and pitted, azonate, context pale yellow when fresh (L), pale cream or pale pinkish when dry, soft and spongy, punky, about 1 5 cm thick, the hyphae much branched, thin-walled to moderately thick-walled, 3–5 μ in diameter, tubes white, 2–3 mm long,[1] mouths white to yellowish, circular to irregular, averaging 4 to a mm , the edges thin, entire to somewhat fimbriate, becoming more or less lacerate where the pore surface is inclined, cystidia none, basidia and spores not observed [2]

The character and color of the surface of the pileus are similar to those of *P sulphureus* (Bull) Fries, but the two species may be easily separated by the consistency of the dry context and usually by the color of the tubes In the United States, apparently, the species is known only from Alabama Lloyd's record (6, p 14, note 495) of a collection from New York State was based upon an incorrectly determined specimen of *P distortus* (Schw) Fries

Polyporus cinnamomeus (Jacq) Fries

Polyporus cinnamomeus is commonly separated from *P perennis* (L) Fries by the brighter color of the surface of the pileus In addition, Overholts (11, pp 43, 46) states that the hyphae of *P cinnamomeus* measure 6 12 μ in diameter, whereas the hyphae of *P perennis* measure but 5 6 μ in diameter Shope (15, pp 353, 355) found the hyphae to be of the same diameter (6–8 μ) for both

[1] The specimen was sterile and probably immature, therefore the tube lengths as given here may be too short for mature specimens

[2] Lloyd (7, p 16, note 690) writes of a specimen received from Japan "Spores I judge, are subglobose, about 4 mic although most of them in this specimen are collapsed and appear reniform "

species Although Overholts' measurements appear to hold for eastern collections of these species, these conflicting statements in the literature and the relative and often perplexing nature of a color separation indicate the need for an additional character to distinguish these species Apparently such a character is found in the shape of the spores

If one accepts Overholts' definition of these species, the spores of *P perennis* (Fig 5 *G*) are usually one-guttulate, and either lack

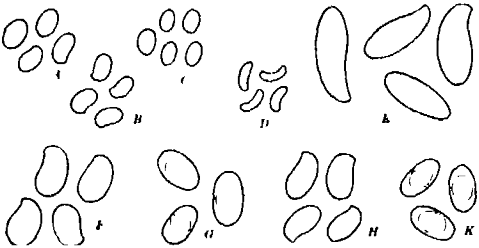


Fig 5 Basidiospores from the fruiting bodies of *A Polyporus floriformis* *B, Polyporus semisupinus* *C* type of *Polyporus pachycheiles* *D*, type of *Polyporus undosus* *E* type of *Polyporus fagicola* *F Polyporus cinnamomeus* *G, Polyporus perennis* *H* type of *Polyporus splendens* *K*, type of *Polyporus simillimus*

an apiculus or else the apiculus is so small as to be scarcely discernible On the other hand, the spores of *P cinnamomeus* (Fig 5 *F*) lack a guttule, and the apiculus is prominent

The spores (Fig 5 *H*) of the type of *P splendens* Peck (= *P subsericeus* Peck) are similar to those of *P cinnamomeus*, and these names are considered synonymous The spores (Fig 5 *K*) of the type of *P simillimus* Peck are similar to those of *P perennis*, and these names are likewise considered synonymous Lloyd (3, p 166) also reduces these two names of Peck's to synonymy under the same species as given above

Polyporus fagicola Murr

(Plate XV, Figs. 3–4)

In the original description of *Polyporus fagicola* Murr (9, p 35) Murrill expressed no opinion concerning its relationships The spores of the type specimen, a portion of which was obtained through

the courtesy of F J Seaver, of the New York Botanical Garden, were hyaline, smooth, cylindric-ellipsoid to subfusiform (Fig 5 *E*), and measured 11–15 × 4 5-5 5 μ, rather than 6–7 × 3–4 μ, as reported by Murrill The spores are of the size and shape of those of *P squamosus* (Huds) Fries Intermediate forms between the typical sporophore of *P squamosus* and that of *P fagicola* have been found, the latter appears to be nothing else than a diminutive form of *P squamosus*

P pennsylvanicus Sumst , a segregate of *P squamosus*, differs from *P fagicola* in the absence of scales on the pileus and in the somewhat larger pores These characters intergrade, and the two species can scarcely be kept distinct The taxonomy of *P squamosus* and its allies would perhaps be clarified by placing *P pennsylvanicus* in synonymy with *P fagicola* and reducing the latter species to varietal rank

Polyporus floriformis Quél

(Plate XV, Fig 1)

In Europe, according to Bresadola (2, Pl 975), *Polyporus floriformis* Quél grows at the base of larch trees Lloyd (5, p 317) reports the substratum to be acerous wood, Overholts (11, p 38) states that the species grows on dead wood of deciduous trees

During the fall of 1932 the writer collected this species at the base of a larch tree near Sugarloaf Lake, west of Chelsea, Michigan The pileus when fresh was pure white and tough to subcoriaceous, and the flesh had a slightly acid taste The species is very closely related to *P semisupinus* Berk , which occurs on deciduous wood, it may be questioned whether the two should be kept distinct The microscopic characters (Figs 5 *A*, *B*) are very similar, the two species appear to differ only in the color changes which take place upon drying In *P floriformis* the discoloration of the pileus is brownish, in *P semisupinus* the discoloration is decidedly yellowish and the pileus becomes more or less laccate, with resinous streaks (see discussion under *P semisupinus*, p 146) No collections from a deciduous substratum have been seen which correspond with the collection on larch

But few collections of these species have been examined, until an opinion can be based upon a larger number of specimens than are now available it seems best to retain them as distinct species

Polyporus iowensis Lloyd

(Plate XV Fig 5)

Lloyd (8, p 1363 and Pl 344, Fig 3257) described *Polyporus iowensis* Lloyd as having the appearance of *P trabeus* Fries (*sensu* Lloyd), but with globose spores During October, 1932, a specimen of this species was collected on a deciduous substratum near Ann Arbor, Michigan, by A H Smith It was identified by comparison with a part of the type collection presented to the Herbarium of the University of Michigan by G W Martin of the University of Iowa Since the Ann Arbor collection varies somewhat from the type specimen, and since it is apparently the only other collection of this species, it seems desirable to present a redescription based upon the two collections

Pileus sessile, solitary or imbricate, soft and watery when fresh, rather rigid when dry, 2 4 × 3–5 × 0 3–2 cm , surface white when fresh, yellowish to somewhat brownish when dry, nearly smooth to somewhat roughened with matted clumps of short hairs, azonate margin thin, acute, sometimes resinous-appearing when dry, narrowly sterile below context white, drying white or in age becoming brownish, radially fibrous, soft, friable, azonate, the hyphae of two kinds strand hyphae, which are moderately thick- to thin-walled, rarely branched, 4 6 μ in diameter, with cross walls but very seldom with clamps, and binding hyphae, which are thin-walled, rarely branched, 3 5 μ in diameter, clamps very abundant, usually at every septum, tubes white when fresh, yellowish to brownish when dry, 0 3 1 cm long, mouths concolorous, sometimes glistening, angular, averaging 4 5 to a mm , the edges thin, entire to fimbriate, cystidia none, basidia not observed, spores hyaline, smooth, broadly ellipsoid, often one-guttulate, 3 5 4 × 2 5 μ

The species is very closely related to *P galactinus* Berk In one imbricate specimen of *P galactinus* examined the context varied from the usual hard, strongly zonate condition to a rather soft, nearly azonate one similar to that found in *P iowensis* Also in the latter species the surface of the pileus is often roughened, owing to matted hairs, much as in *P galactinus*, but the roughening is not so extensive or so well developed *P iowensis*, though very closely related to *P galactinus*, seems sufficiently well marked to warrant retaining it as a distinct species

Polyporus semisupinus Berk & Curt

(Plate XV Fig 2)

According to Lloyd (5, p 316), the type of *Polyporus semisupinus* is the same as collections which Peck named *P semipileatus* In the two original descriptions, however, there is a difference which can scarcely be reconciled Berkeley (1, p 50) describes *P semisupinus* as "ochraceus, pileo postice laccato-glabrato," whereas Peck (12, p 43) writes Pileus ' subvillose, whitish, or alutaceous " Neither the type specimen of *P semipileatus*, nor any other specimen of this species seen by the writer, agrees with the description of *P semisupinus* There occurs in the northern states, however, a species which corresponds to Berkeley's description The original specimen was reflexed, but, as illustrated, specimens are sometimes substipitate as well The pileus dries decidedly yellowish, often appearing thinly laccate, and with radial resinous streaks The spores (Fig 5 *B*) are ellipsoid to ovoid, 2 5–4 × 2–3 μ As previously stated, the species is closely related to *P floriformis*

The macroscopic and microscopic (Fig 5 *C*) characters of the type of *P pachycheiles* Ell & Ev agree with *P semisupinus* as here described, and the former is considered a synonym of the latter species Murrill (10, p 34) also considers *P pachycheiles* a synonym of *P semisupinus*

The writer is indebted to Dr L O Overholts for confirming the identification of a specimen of this species

Polyporus undosus Peck

(Plate XIV, Figs. 4 5)

The substratum of the type of *Polyporus undosus* Peck and, apparently, of all subsequently reported collections, has been hemlock During the summer of 1932 the writer collected a specimen of this species on beech at Warrensburg, New York, and identification was made by comparison with the type collection

According to Lloyd (5, p 318), the spores of this species are "flattened, elliptical, 3 × 4 mic on broad view, 2 × 4 mic on narrow view " The spores of the type collection (Fig 5 *D*), however, and of all other collections (four) examined, are allantoid, 4–5 × 1 5 2 μ The subcoriaceous texture, thin context, and allantoid spores relate the species to the Polystictus section of the genus Polyporus

rather than to the more fleshy forms among which it is usually placed Specimens resemble small forms of *P biformis* and may easily be confused with it, but the wavy margin and smaller spores distinguish it

Acknowledgments are made to Dr E B Mains and to Dr D V Baxter for aid in the preparation of the manuscript

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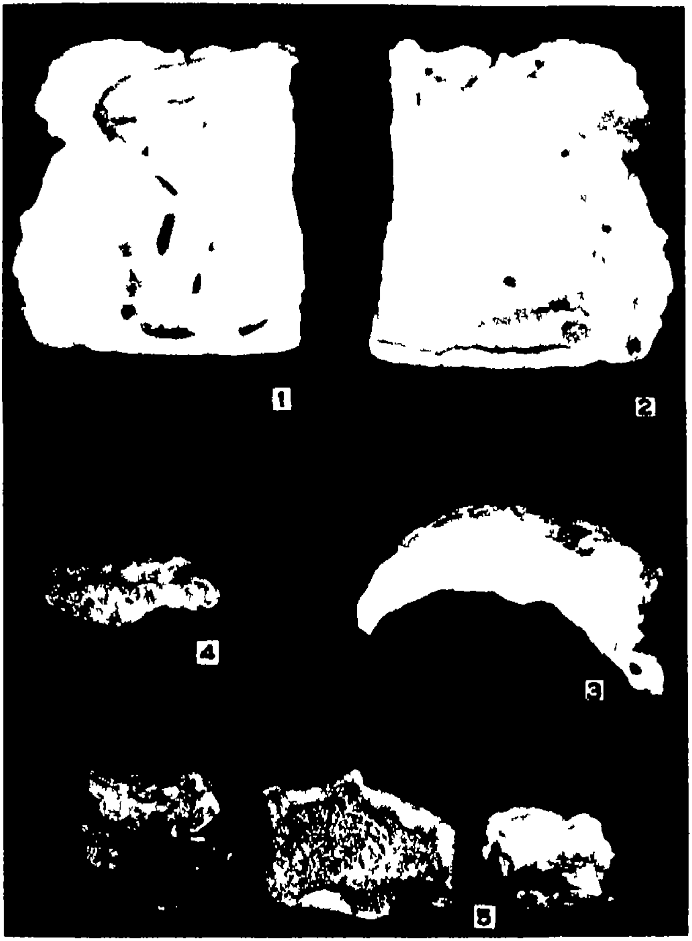
PLATE XIV



Figs. 1–3. *Polyporus albidus*
Fig. 4. Specimen of *Polyporus undosus* from Warrensburg, New York
Fig. 5. Specimens from the type collection of *Polyporus undosus*

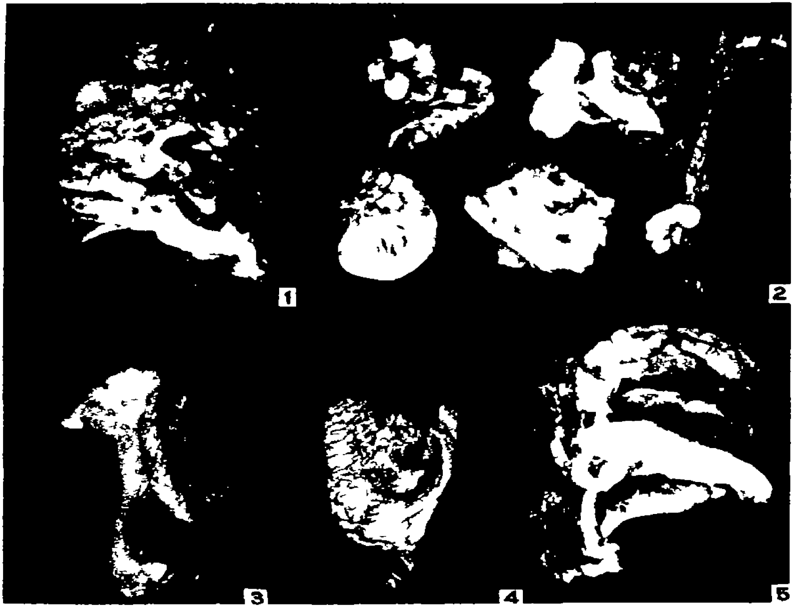


Fig. 1 [illegible]
Fig. 2 [illegible]
Figs. 3, 4 [illegible]
Fig. 5 [illegible]

NEW SUMATRAN PLANTS I

ELMER D MERRILL

THIS paper is based on several extensive collections of Sumatran plants, including those secured by Professor H H Bartlett of the University of Michigan in 1927, Mr Carel Hamel in 1928, Rahmat Si Toroes, employed by Professor Bartlett and working under the general supervision of Mr Hamel, in 1927 and 1928, and a partial set of those collected by Dr H S Yates from 1925 to 1927 These collections were mostly made in Asahan, Sumatra East Coast, although some of the material came from neighboring political subdivisions Sets of the first three collections are deposited in the herbarium of the University of Michigan, the United States National Herbarium, and the New York Botanical Garden, the remaining duplicates will be distributed by Professor Bartlett to other botanical institutions The sets of duplicates of the Yates collection were rather widely distributed to various botanical institutions while I was at the University of California the most nearly complete one is in the herbarium of that institution Dr Yates' personal set, not containing the numbers from the West Coast, is at the University of Michigan

In this contribution sixty-eight species and varieties of phanerogams are described as new among these is one new genus of the Cucurbitaceae The types, unless otherwise stated in the text, are in the herbarium of the New York Botanical Garden In addition, there are notes on a few other species, not all Sumatran, but included because of problems in relation to their distribution, or nomenclature and synonymy, which arose during the study of the Sumatran collections In the extensive collections available there are numerous other species of special interest, many of which are apparently new or new to Sumatra As the opportunity presents itself these will be studied, but in many instances it seems desirable to have comparisons made with extant types, whereas in some cases supplementary material is needed

The flora of Sumatra has been very imperfectly investigated, and at the present time it is impossible to estimate approximately how many species are known from that great island Its flora is in general similar to that of the Malay Peninsula, of Java, and of Borneo, geographic entities situated on the greatest submarine bank in the world This great Sunda shelf, extending southward from Asia, is about 1,500 miles wide and carries upon it the Sunda Islands It has a remarkably even surface, the waters that cover it average only about 60 meters in depth A change in sea level of only 45 meters would today unite Sumatra, Java, Borneo, and the Palawan-Calamian group in the Philippines with Asia In the Pliocene and Pleistocene it seems to be evident that, at least at times, all the islands mentioned formed a part of the Asiatic continent, and that in these two geological periods intermigrations of both plants and animals were not restricted by impassable sea barriers This geological history thus accounts, in part, for the marked similarities that exist between the flora of the Sunda Islands and that of the Malay Peninsula

The botanical literature appertaining to Sumatra is very widely scattered, and no modern publication exists in which our knowledge is summarized In 1860–61 Miquel, in his basic *Prodromus Florae Sumatranae*,[1] summarized what was then known regarding its phanerogamic flora, listing about 1,350 species Since that time the number of known species has certainly been more than doubled, probably more than trebled, yet the number of still unknown ones occurring in Sumatra is probably larger than the list of known species A few of the more important papers issued since 1861 on the Sumatran flora are as follows

HASSELT, A L, AND BOERLAGE, J G Bijdragen tot de kennis der Flora van Midden-Sumatra, in Veth, P J, Midden-Sumatra, 4 (2) 1–49, Pls 1–8 1884

KOORDERS-SCHUMACHER, A Systematisches Verzeichnis der zum Herbar Koorders gehörenden, in Niederländisch-Ostindien, besonders in den Jahren 1888–1903 gesammelten Phanerogamen and Pteridophyten Abteilung II, Sumatra pp 1–62 1910–11

[1] MIQUEL, F A W, *Florae Indiae Batavae. Supplementum I Prodromus Florae Sumatranae*, xx + 656, Pls 1–4 1860–61 There is another edition under the title *Sumatra zijne Plantenwereld en hare Voortbrengselen*, xx + 656, Pls. 1–4 1862 German edition, *Sumatra, seine Pflanzenwelt und deren Erzeugnisse*, xxiv + 656, Pls 1–4 1862 The technical parts of the text are the same in all three editions.

RIDLEY, H N Results of an Expedition to Korinchi Peak Sumatra Journ Fed Malay States Mus 8 (4) 1 145 Pls 1–4 1917

RIDLEY, H N A Botanical Excursion to Northern Sumatra Journ As Soc, Malay Branch 1 46 113 1923

RENDLE, A B Dr H O Forbes Malayan Plants Journ Bot 62 Suppl 1–48 1924, 63 Suppl pp 49–136, 2 f 1925

The total number of titles of papers containing direct references to Sumatran species is possibly as many as a thousand As compared with the Malay Peninsula, Java, and the Philippines, the flora of Sumatra is very imperfectly known, ranking with Borneo in this regard, but probably with a smaller percentage of its species known than is the case with Borneo

The student who concerns himself with the study of Sumatran plants is therefore greatly handicapped because of the fragmentary and widely scattered nature of the literature Most generic identifications can be made from the general published floras of British India, the Malay Peninsula, and Java The most useful and usable publication of this type that has yet appeared, but, unfortunately one never completed, is that by King, and King and Gamble, "Materials for a Flora of the Malayan Peninsula," which appeared in twenty-five parts in the *Journal of the Asiatic Society of Bengal* from 1889 to 1915 and which was reprinted in five volumes This excellent work covers all the species then known to occur in the Malay Peninsula, from the Ranunculaceae to the Salicaceae, following the Bentham and Hooker system The more recent *Flora of the Malay Peninsula*, by H N Ridley (5 vols, 1922–25), although including all families of flowering plants and covering the same area, is, because of its manifest imperfections, a much less valuable publication In both works the student will find descriptions of most of the genera known from Sumatra, as well as descriptions of very many of the known Sumatran species, although, of course, Sumatran endemics are not included These two works on the Malay Peninsula are the nearest approach to anything that has yet been published which even approximately covers the Sumatran flora other than the much older work of Miquel mentioned above So far as I can judge at the present time, somewhere between 40 and 50 per cent of the known Sumatran species are endemic, that is, known only from that island, so that no published flora of any neighboring region can be expected to be more than an aid to the determination of Sumatran material

ARACEAE

Homalomena longipes, sp. nov. § Chamaecladon (Tab. XVI).

Herba parva, caudiculo saltem 7 cm. longo, circiter 5 mm. diametro; foliis longe (8 ad 12 cm.) petiolatis, supra glabris, subtus puberulis, chartaceis, anguste oblongo-obovatis vel late oblongo-oblanceolatis, acutis vel breviter obscure acuminatis, basi cuneatis, 13 ad 15 cm. longis, 5 ad 5.5 cm. latis, nervis primariis utrinque circiter 12, curvato-ascendentibus, subtus distinctis, elevatis, intermediis gracilioribus; petiolo laminam subaequante basi ca. 3 cm. vaginato; spathis oblongis, subcylindricis, circiter 1 cm. longis, curvato-apiculatis, pedunculo tenui, usque ad 4 cm. longo.

Sumatra, East Coast, near Taloen Djoring, Silo Maradja, Asahan, *Rahmat Si Toroes 14*, December, 1927.

A species apparently belonging in the group with *Homalomena lancifolia* Hook. f., but with much smaller, differently shaped leaves and smaller spathes. In the present species the leaves are widest at about the upper two thirds, and in outline are in general narrowly oblong-obovate.

FAGACEAE

Castanopsis conspersispina, sp. nov. (Tab. XVII).

Arbor, ramulis sordide breviter subfurfuraceo-pubescentibus, ramis perspicue lenticellatis, ramulis ultimis circiter 1.5 mm. diametro; foliis oblongis vel oblongo-ellipticis, integris, acutis vel breviter acuminatis, basi late acutis vel subrotundatis, coriaceis, circiter 10 cm. longis, 3.5 ad 4 cm. latis, supra olivaceis, nitidis, subtus subcinereo-argyraceis, minute puberulis, nervis primariis utrinque circiter 12, gracilibus, supra vix impressis, subtus perspicuis, reticulis primariis gracilibus, subparallelis; petiolo cinereo-puberulo, circiter 1 cm. longo; fructibus inaequilateraliter ovoideo-ellipsoideis, circiter 2.5 cm. longis, rotundatis, leviter cinereo-puberulis glabrescentibus, involucro fragili, extus spinis conspersis fasciculatis rigidis subulatis leviter curvatis cinereo-puberulis 5 ad 7 mm. longis ornato, fasciculis haud stipitatis, irregulariter dispositis; glande 1, pericarpio cupulae adnato, intus villoso.

Sumatra, East Coast, Dolok Maradja, Asahan, *Rahmat Si Toroes 1476*, October 7-8, 1928.

A species apparently allied to *Castanopsis argyrophylla* (Wall.) King, of Burma and Tenasserim, but with smaller leaves which are minutely yet densely puberulent beneath, where is the rather widely scattered tufts of spines by no means cover the outer surface of the involucre, but leave conspicuous open spaces on both the dorsal and ventral sides.

MORACEAE

Ficus Bartlettii, sp. nov. § Covellia

Arbor, partibus iunioribus et ramulis et petiolis consperse adpresse pallide hirsutis, ramulis gracilibus, ultimis 1 ad 1.5 mm. diametro, foliis chartaceis vel subcoriaceis, laevibus, olivaceis plerumque deorsum inaequilateralibus, alternis oppositisque, integris, oblongo-ovatis vel oblongo-ellipticis, 9 ad 15 cm. longis, 4 ad 6 cm. latis, apice breviter abrupteque acuminatis, basi acutis, utrinque puncticulatis, glabris, vel iunioribus supra parcissime hirsutis et ad costam nervosque consperse hirsutis, nervis primariis utrinque 6 ad 8, distinctis, subtus elevatis, curvato-anastomosantibus, reticulis primariis laxis, haud perspicuis, petiolo adpresse hirsuto, 5 ad 7 mm. longo, stipulis ovato-lanceolatis, acuminatis, glabris, circiter 8 mm. longis, inflorescentiis caulinis, ramis specialibus usque ad 1.5 cm. longis, crassis, vix vel breviter ramosis, cicatricibus multis perspicuis notatis, pedunculis subfasciculatis, gracilibus, consperse breviter subadpresse hirsutis, 2.5 ad 3.5 cm. longis, 2 ad 6 mm. infra receptaculum bracteas binas rigidas breves ferentibus, receptaculis numerosis, longe pedunculatis, ovoideo globosis, circiter 1 cm. diametro, parce adpresse hirsutis, intus parce hirsutis, ostiolo perspicuo, floribus ♀ cecidiophoris numerosis, cum pedicellis 2 mm. longis, perianthio 0, ♂ paucis tantum circum ostiolum, anthera 1.

Sumatra, East Coast, Dĕlĕng Piso-piso, Karo Plateau, *Bartlett 6546*, January 31, 1927.

A species characterized within the section and among those with the fruits subfasciculately arranged on very short lateral or cauline branches or tubercles by its small and long-peduncled receptacles. In the material examined most of the leaves are alternate, but where they are opposite the leaves in each pair are distinctly unequal in size and somewhat different in shape, the smaller one of each pair is nearly equilateral, elliptic, and about one half as large as its opposing one.

Ficus Yatesii, sp nov § Covellia (Tab XVIII)

Arbor subglabra, ramis ramulisque gracilibus, ramulis consperse adpresse hirsutis, ultimis 1 ad 1 5 mm diametro, foliis late oblongo lanceolatis, alternis, chartaceis, integris, 6 ad 11 cm longis, 2 ad 3 4 cm latis, olivaceo-brunneis, leviter inaequilateralibus, utrinque subaequaliter angustatis, basi acutis, apice tenuiter acuminatis, utrinque pallide punctatis, glabris vel ad costam nervosque parce consperse adpresse albido-hirsutis, nervis primariis utrinque circiter 7, distinctis, curvatis, obscure arcuato-anastomosantibus, petiolo 3 ad 4 mm longo, parce adpresse hirsuto, stipulis lanceolatis, acuminatis, usque ad 9 mm longis, inflorescentiis caulinis, receptaculis in tuberculis usque ad 2 cm diametro dispositis, tuberculis breviter crasseque ramosis, ramis haud 1 cm longis, 3 ad 5 mm crassis, cicatrices multas ferentibus, receptaculis turbinato-obovoideis vel turbinato-globosis, usque ad 1 cm diametro, parce albido-hirsutis, glabrescentibus, pedunculo 1 cm longo, leviter pubescenti, bracteis 3, ovatis, obtusis, vix 1 mm longis, circiter 2 mm infra receptaculis insertis, floribus fertilibus numerosis, pedicellis usque ad 1 mm longis, perianthio 0

Sumatra, East Coast, Siantar to Parapat, Simeloengoen, *Yates 1670*, June, 1925, altitude 1000 m

This species curiously resembles various Malay Peninsula collections distributed as *Ficus polysyce* Ridl, including *Henderson 23320, 23575, 23494*, characterized by their small globose receptacles, which are less than 1 cm in diameter Ridley's species was described as having elliptic or lanceolate leaves and the receptacles as being 0 75 inch long and thick Ridley's description, *Fl Malay Penin*, 3 342 1924, differs but very slightly from the original, but certainly his figure 156, with ovate, shallowly cordate leaves, does not represent *Ficus polysyce* Ridl

FICUS PARIETALIS Blume var **hirsutissima**, var nov

A typo differt receptaculis subsessilibus, obovoideis, densissime longe fulvo-hirsutis, ramulis densissime fulvo-hirsutis et foliis subtus dense molliter villosis

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 2212* (type)

As different as this is from the more typical forms of Blume's

species with distinctly peduncled, sparingly hirsute receptacles and sparingly hirsute leaves, it seems doubtful whether a distinct species is represented here, because of apparently intermediate forms, yet I have seen no specimens so densely pubescent as is this Sumatran form Typical *Ficus parietalis* Blume, *Yates 1935*, *Bartlett 7186*, no collector (probably *Korthals*), is not uncommon in Sumatra as it is in the Malay Peninsula The Sumatran species, *Ficus tabing* Miq and *F phlebophylla* Miq , are probably correctly reduced to *F parietalis* Blume by King In *Yates 2212* the few staminate flowers observed all have peculiarly large pistillodes, about the size of the ovaries of the numerous gallflowers

ROSACEAE

Photinia Bartlettii, sp nov

Frutex vel arbor parva, glabra, ramis ramulisque plus minusve rugosis, ramulis lenticellatis, ultimis circiter 2 mm diametro, foliis membranaceis vel chartaceis, ellipticis, 5 ad 7 cm longis, 2 5 ad 3 5 cm latis, brunneis, brevissime abrupteque acuminatis, basi acutis vel obtusis, margine irregulariter crenulato vel crenulato-serrulato, dentibus parvis, obtusis, nervis primariis utrinque circiter 9, gracilibus, subascendentibus, distinctis, subtus elevatis, petiolo 1 5 ad 2 cm longo, paniculis terminalibus, glaberrimis, 3 ad 5 cm longis, ramis primariis paucis, usque ad 2 5 cm longis, pedicellis 3 ad 5 mm longis, calycis tubo sursum abrupte ampliato et 3 mm diametro, deorsum vix 1 mm diametro, lobis triangulari-ovatis, acutis, reflexis, 1 5 mm longis, petalis ellipticis vel obovatis, reflexis, deciduis, 3 5 ad 4 mm longis, brevissime unguiculatis, staminibus circiter 25, filamentis glabris, ad 3 mm longis, ovario 3-loculari, stylis 4 mm longis quorum ramis 3 circiter 3 mm longis

Sumatra, East Coast, Dělěng Singkoet, north of Běrastagi, Karo Plateau, *Bartlett 8662*, June 27, 1927

Resembling in many characters the collective species currently known as *Photinia* (*Pourthiaea*) *arguta* Wall , but entirely glabrous It does not conform to the characters of any of the southern Asiatic and Malaysian species known to me

Pygeum myriandrum, sp nov

Arbor parva, floribus plus minusve pubescentibus exceptis glabra, ramis teretibus, laevibus, consperse lenticellatis, purpureo-

brunneis, ultimis circiter 2 mm diametro foliis subcoriaceis, nitidis, ellipticis, 12 ad 17 cm longis, 8 ad 10 cm latis, acutis vel breviter acuminatis, basi late rotundatis, ad petiolum glandulas binas papilliformes perspicuas ferentibus, supra pallidis, subtus densissimo puncticulatis, brunneis, nervis primariis utrinque circiter 10, subtus perspicuis, elevatis, haud vel obscure arcuato-anastomosantibus, reticulis subobsoletis, petiolo 1 5 ad 2 cm longo, racemis solitariis, circiter 10 cm longis, ut videtur paucifloris, pedicellis 2 ad 3 mm longis, glabris, cupulis subcylindricis, 2 5 mm longis, extus breviter ferrugineo-pubescentibus, intus leviter villosis, lobis 10, pubescentibus, oblongo-ovatis, obtusis, circiter 1 mm longis, filamentis circiter 75, glabris, usque ad 4 mm longis, ovario ovoideo, glabro, vel basi plus minusve ferrugineo-villoso

Sumatra, East Coast, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 6871*, March 12, 1927

Perhaps most closely allied to *Pygeum polyadenium* Koehne, but the leaves entirely glabrous, not densely strigose on the midrib and nerves beneath

Pygeum sterrophyllum, sp nov (Tab XIX)

Arbor parva, ramulis parce pubescentibus, racemis dense ferrugineo-villosis, ramis glabris, atris, parce lenticellatis, ramulis circiter 1 mm diametro, foliis rigidis, oblongo-ovatis vel late oblongo-lanceolatis, 6 ad 8 cm longis, 2 ad 3 5 cm latis, tenuiter acuminatis, plerumque falcatis, basi rotundatis vel acutis, haud glandulosis, glandulis secundariis late conspersis vel nullis, nervis primariis utrinque circiter 9, supra cum reticulis distincte impressis, subtus gracilibus, haud perspicuis, arcuatis, reticulis saepe subobsoletis, supra glabris, olivaceis, subtus brunneis, junioribus obscure consperse pubescentibus, glabrescentibus, petiolo 7 ad 11 mm longo, pubescenti, racemis plerumque 2 vel 3, axillaribus et in axillis defoliatis, 2 5 ad 3 cm longis, dense ferrugineo-pubescentibus, floribus numerosis, albidis, cupulis circiter 3 mm diametro, 2 5 mm longis, extus dense ferrugineo-pubescentibus, lobis circiter 10, pubescentibus, oblongis, 1 mm longis, staminibus circiter 20, filamentis glabris, usque ad 5 mm longis, ovario glabro, ovoideo, stylis 4 5 mm longis

Sumatra, Tapianoeli, summit of Dolok Soeroengan, Habinsaran, *Bartlett 8014*, May 18, 1927

A species characterized by its small, often falcate, conspicuously

acuminate rigid leaves, and its entirely glabrous ovaries It does not appear to be referable to any of the rather numerous Malaysian species recognized by Koehne in *Bot Jahrb* 51 177 224 1913, and, so far as I can determine from the rather unsatisfactory descriptions, it is different from both *Pygeum glabrifolium* Bak f and *P viride* Bak f, based on Forbes' Sumatran collections and described in 1924

LEGUMINOSAE

Bauhinia gracilipes, sp nov § Phanera (Tab XX)

Frutex scandens, inflorescentiis consperse ferrugineo pubescentibus exceptis glaber, ramis teretibus, ramulis ultimis 2 ad 2 5 mm diametro, foliis ovatis, subcoriaceis, 8 ad 10 cm longis, 6 ad 8 cm latis, supra olivaceis, nitidis, subtus pallidioribus, utrinque glaberrimis, basi late rotundatis 7-nervus, apice subtruncato-erosis, sinu circiter 1 cm lato, dentibus terminalibus distantibus, brevibus, latis, obtusis, vix 3 mm longis, petiolo 4 ad 5 5 cm longo, cirrhis paucis, glabris, inflorescentiis subpaniculatis, 15 ad 25 cm longis, ramis primariis 6 ad 8 cm longis, conspersе adpresse ferrugineo-pubescentibus, floribus racemosis, flavidis, tarde rubris, longissime graciliterque pedicellatis, bracteis ellipticis vel ovatis, 4 ad 5 mm longis, obscure pubescentibus, obtusis vel acutis, bracteolis anguste oblongis, circiter 3 mm longis, pedicellis usque ad 6 cm longis, subaequalibus, calycibus clavatis, tubo 2 ad 2 3 cm longo, 1 mm diametro, conspersе pubescenti, sulcato-striato, extremitate ovoideo-ellipsoidea, circiter 4 mm diametro, sepalis glabris vel iunioribus obscure pubescentibus, 5 ad 6 mm longis, oblongis, acutis, petalis obovatis vel oblongo-obovatis, rotundatis, basi acutis, 1 6 ad 1 8 cm longis, intus glabris, extus plerumque ad costam nervosque plus minusve pubescentibus, ovario stipitato, compresso, ad marginem ferrugineo-pubescenti

Sumatra, East Coast, near Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7600*, May 4, 1927

A species characterized by its glabrous, peculiarly truncate-erose leaves, the tips appearing as if a small piece had been bitten out, leaving two distinct broad, short terminal teeth, as well as by its very slender elongated pedicels, clavate buds, and slender, greatly elongated calyx tubes It is allied to *Bauhinia bidentata* Jack of Sumatra and the Malay Peninsula, differing in numerous characters, notably in its lax inflorescences, and scattered, very

long pediceled flowers The flowers are borne in racemes, which are in turn racemosely arranged along terminal or lateral branches, which sometimes are provided with a few reduced leaves *Bauhinia pyrrhaneura* Korth, as illustrated by Korthals, somewhat resembles the present species, but differs notably in its pubescent, acuminate or at most very slightly retuse leaves and short stout calyx tubes, which about equal the sepals in length

Bauhinia Rahmatii, sp nov § Phanera (Tab XXI)

Frutex ut videtur scandens, ramulis, inflorescentiis et foliis subtus perspicue molliter castaneo-villosis, ramulis ultimis 2 5 mm crassis, foliis coriaceis, rigidis, subreniformibus, 3 5 ad 6 5 cm longis, 5 ad 7 5 cm latis, supra castaneis, glabris, subtus molliter villosis, basi distincte cordatis, 11-nerviis, apice usque ad ½ divisis, lobis late rotundatis, costa in sinum acutum breviter producta, petiolo dense castaneo-villoso, 2 ad 2 3 cm longo, stipulis late ovatis, villosis, ad 7 mm longis, inflorescentiis lateralibus terminalibusque, simpliciter racemosis, paucifloris, densis, usque ad 5 cm longis, alabastris cylindricis vel cylindrico-obovoideis, floribus saltem 2 5 cm longis, breviter crasseque pedicellatis, bracteis bracteolisque extus dense castaneo-villosis, intus glabris, bracteis orbiculari-ovatis, usque ad 9 mm longis, bracteolis binis, quam bracteis paulo minoribus, rotundatis, pedicellis crassis, circiter 3 mm longis, calycis tubo brevi, circiter 5 mm longo et 6 mm crasso, lobis 5, oblongis, coriaceis, 1 5 cm. longis, 4 mm latis, acutis, extus dense villosis, intus glabris, petalis extus nitide castaneo-villosis, intus glabris, ellipticis vel oblongo-obovatis, rotundatis, breviter unguiculatis, basi obscure biauriculatis, immaturis circiter 2 cm longis, staminibus 5, quorum 3 fertilibus, 2 sterilibus, filamentis glabris, 3 fertilibus circiter 13 mm longis, 2 sterilibus circiter 5 mm longis, antheris ellipsoideis, 6 mm longis, ovario stipitato, cum stylo crasso dense villoso, stigmate 3 mm diametro, ovulis 2, leguminibus oblongo-obovatis, basi late acutis, apice obtusis, breviter apiculatis, circiter 6 cm longis et 3 mm latis, valvis extus nitidis, castaneis vel nigris, leviter pubescentibus, glabrescentibus, seminibus solitariis, ellipticis, compressis, nigris, 1 8 cm longis

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasaran) and Damoeli, Koealoe, *Rahmat Si Toroes 161* (type), *1511*, February and October, 1928

A species distinguished by its indumentum and vegetative characters as well as by its short simple, densely flowered racemes, its conspicuous bracts and bracteoles, and its five stamens, of which the three longer ones are fertile, the sterile ones are less than half as long

Whitfordiodendron sumatranum, sp nov

Frutex alte scandens, inflorescentiis exceptis glaber, ramis teretibus, ramulis circiter 3 mm crassis, foliis 15 ad 20 cm longis, plerumque 5-foliolatis, foliolis subcoriaceis, ellipticis, 6 ad 10 cm longis, 3 ad 5 5 cm latis, obtuse acuminatis, basi rotundatis, nervis primariis utrinque 4 ad 6, petiolulis 5 ad 8 mm longis, paniculis ut videtur in axillis superioribus, circiter 15 cm longis, multifloris, alabastris in ramulis densissime confertis, bracteis rhomboideo-obovatis, acuminatis, utrinque pubescentibus, circiter 6 mm longis et 4 mm latis, deciduis, in inflorescentiis immaturis dense imbricatis, bracteolis binis, supra calycis basin insertis, deciduis, oblanceolatis, acuminatis, 6 mm longis, pubescentibus, floribus rubro-purpureis, circiter 13 mm longis, calycibus circiter 5 mm longis latisque, plus minusve pubescentibus, lobis parvis, vexillari lato, obscure retuso, ceteris angustis, acuminatis, petalis rubro-purpureis, extus pubescentibus, vexillo circiter 9 mm lato, rotundato, basi late cuneato, haud auriculato, intus in parte media pubescenti, alis anguste oblongis, obtusis, 3 mm latis, basi leviter inaequilateraliter hastatis, ovario biovulato, pubescenti

Sumatra, East Coast, Boenoet, Asahan, *Yates 1261* (type) 1907, January 4, 1925, Goerach Batoe, Asahan, *Yates 1907*, December 20, 1925

The alliance of this species is manifestly with the Bornean *Adinabotrys myrianthus* Dunn, from which it differs in numerous details, especially in its smaller leaflets, larger bracts, and distinctly larger flowers

Whitfordia Elmer (1910), the name by which this genus was first described, is invalidated by Whitfordia Murrill, an earlier name proposed for a genus of fungi In the same year Mr Elmer proposed the new generic name Whitfordiodendron, and a year later Mr Dunn independently redescribed the same group as Adinabotrys Whitfordiodendron Elmer (1910) has clear priority over Adinabotrys Dunn (1911), see Dunn in *Kew Bull*, 193 1911, 363

1912. Now that diagnoses in languages other than Latin published before 1932 have been validated by action of the Fifth International Botanical Congress, there is no reason why Elmer's earlier name should not be accepted. The species are:

Whitfordiodendron atropurpureum (Wall.) comb. nov.

Pongamia atropurpurea Wall., *Pl. As. Rar.* 1: 70. Pl. 78. 1830; List no. 5910. 1832.
Millettia atropurpurea Benth., in Miq. *Pl. Jungh.* 249. 1852.
Adinabotrys atropurpureus Dunn, in *Kew Bull.* 197. 1911.
Burma to the Malay Peninsula, Sumatra and Java.

Whitfordiodendron erianthum (Benth.) comb. nov.

Millettia eriantha Benth., in Miq. *Pl. Jungh.* 250. 1852.
Adinabotrys erianthus Dunn in *Kew Bull.*, 194. 1911.
Malay Peninsula.

Whitfordiodendron myrianthum (Dunn), comb. nov.

Adinabotrys myrianthus Dunn in *Kew Bull.* 196. 1911.
Borneo.

WHITFORDIODENDRON NIEUWENHUISII (J. J. Sm.) Merr. in *Univ. Calif. Publ. Bot.* 15: 106. 1929.

Millettia Nieuwenhuisii J. J. Sm. in *Bull. Dept. Agr. Ind. Neerl.* 3: 17. 1906; *Ic. Bogor.* 3: Pls. 230, 231. 1907.
Adinabotrys Nieuwenhuisii Dunn in *Kew Bull.* 196. 1911.
Borneo.

WHITFORDIODENDRON SCANDENS Elm. ex Dunn, in *Kew Bull.*, 364. 1912, in syn.

Whitfordia scandens Elm. in *Leafl. Philip. Bot.* 2: 689. 1910.
Adinabotrys scandens Dunn in *Kew Bull.*, 364. 1912.
Philippines.

OXALIDACEAE

Sarcotheca ferruginea, sp. nov. (Tab. XXII)

Frutex vel arbor parva, ramulis, inflorescentiis et foliis subtus perspicue ferrugineo-pilosis, ramis glabris, ramulis teretibus, circiter 1 mm. crassis; foliis oblongo-ovatis vel oblongo-lanceolatis, subcoriaceis, 5 ad 10 cm. longis, 1.5 ad 3.5 cm. latis, supra glabris, nitidis, pallidis vel brunneis, subtus ferrugineis, basi late acutis vel rotundatis, haud triplinerviis, apice distincte acuminatis, nervis primariis utrinque 4 ad 6, distinctis, curvato-ascendentibus; inflorescentiis axillaribus terminalibusque, racemosis, 2 ad 3 cm. longis, dense ferrugineo-pubescentibus, floribus ignotis; fructibus ellipsoideis vel oblongo-ovoideis, usque ad 1 cm. longis, glabris vel parcissime conasperse ferrugineo-villosis, sepalis persistentibus ferrugineo-pilosis, anguste oblongis, acutis vel leviter acuminatis, circiter 3 mm. longis.

Sumatra, East Coast, Damoeli, Koealoe, *Rahmat Si Toroes 1370*, September 18, 1928; Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 197, 3,8* (type), February March, 1928.

This is apparently the first representative of *Sarcotheca* to be reported from Sumatra. It is characterized by its simple pinnately nerved leaves and its conspicuous ferruginous indumentum.

EUPHORBIACEAE

Macaranga Bartlettii, sp. nov. § Pachystemon (Tab. XXIII).

Arbor parva, 6 ad 8 m. alta, glabra, ramis ramulisque teretibus, laevis, circiter 4 mm. crassis; foliis alternis, peltatis, chartaceis vel subcoriaceis, triangulari-ovatis, circiter 20 cm. longis, 13 ad 15 cm. latis, haud punctato-glandulosis, basi palmatim 9-nerviis, latissime rotundato-truncatis, sursum angustatis, apice rostrato-acuminatis, margine distanter sinuato-dentato, dentibus brevibus, acutis, inter se 1 ad 1.5 cm. distantibus, nervis primariis sursum basin pinnatim dispositis, utrinque circiter 10, subtus elevatis, perspicuis; petiolo circiter 18 cm. longo ad vel circiter insertionem eglanduloso; infructescentiis lateralibus, brevibus, pedunculatis, cum pedunculo 2.5 ad 3.5 cm. longo, fructibus paucis, sessilibus, in partibus superioribus subcapitatim confertis, turbinatis, circiter 1 cm. diametro, glabris, in partibus superioribus 1–5-rostratis, rostris crassis, plus minusve curvatis, obtusis, circiter 4 mm. longis, deorsum 3 mm. latis, junioribus utrinque dense granuloso-glandulosis, vetustioribus glabrescentibus.

Sumatra, East Coast, near Ack Sordang, Loendoet Concession, Koealoe, *Bartlett 7656*, May 10, 1927, in old jungle and second growth.

Although the staminate flowers are as yet unknown, this species seems to fall in the section Pachystemon. The leaves are very characteristic, being almost triangular-ovate in outline, that is, narrowed upward from the abruptly truncate-rounded base. The petiole is inserted about 3 cm. from the basal margin.

MALLOTUS ARBOREUS Merr. var. **platyphyllus**, var. nov.

A typo differt foliis majoribus, oblongo-obovatis, usque ad 30 cm. longis et 15 cm. latis.

Sumatra, East Coast, Masihi, Asahan, *Yates*.

The specimen has staminate flowers, more nearly complete material may indicate some other disposition of this specimen The type was described in *Univ Calif Publ Bot*, 15 159 1929

AQUIFOLIACEAE

Ilex apiculata, sp nov § Euilex, Paltoria, Vacciniifoliae (Tab XXIV)

Frutex 1 ad 2 m altus, ramis glabris, ramulis angulatis, puberulis, circiter 1 mm crassis, foliis numerosis, parvis, confertis, coriaceis, ellipticis vel oblongo-ellipticis, 1 ad 1 5 cm longis, 5 ad 8 mm latis, nitidis, supra olivaceis, subtus pallidioribus haud punctatis, basi acutis, apice rotundatis, plerumque retusis et breviter crasse apiculatis, margine integro vel iuxta apicem rarissime 1- vel 2-serrato, costa supra leviter impressa, subtus elevata, nervis lateralibus obsoletis, petiolo puberulo, 1 ad 2 mm longo, stipulis subulatis, 1 5 mm longis, floribus axillaribus, solitariis, 4-meris, pedicellis puberulis, usque ad 4 mm longis, bibracteolatis, bracteolis lineari-lanceolatis, acuminatis, 0 8 mm longis, calycibus 2 mm diametro, lobis 4, brevibus, rotundatis, corollae lobis 4 elliptico-ovatis, rotundatis, 2 mm longis, ovario 4-loculari, fructibus ovoideis, rostrato-umbonatis, circiter 4 mm longis, pyrenis plerumque 3

Sumatra, Tapianoeli, summit of Dolok Soeroengan, Habinsaran, *Bartlett 8010*, May 18, 1927

The specimen was first referred to *Ilex Havilandii* Loesen of the section Thyrsoprinus, Racemosae, but on more critical study it seems clearly to belong in the alliance with *Ilex Hanceana* Maxim, and of the species placed here is apparently most closely allied to *Ilex Walkerii* Wight & Gardn of Ceylon The stout short apiculus is really the prolongation of the midrib into the always notched apices of the leaves

Ilex Bartlettii, sp nov § Euilex, Aquifolium (Insignes?)

Arbor glabra, ramis consperse lenticellatis, purpureo-brunneis, ramulis circiter 1 5 mm crassis, foliis coriaceis, supra pallide olivaceis, nitidis, subtus paulo pallidioribus, oblongo-ovatis vel elliptico-ovatis, acuminatis, basi latissime acutis vel rotundatis, margine distincte apiculato-serrato, dentibus 1 ad 1 5 mm longis, incurvatis, costa et nervis et reticulis primariis supra impressis, subtus perspicue

elevatis, nervis primariis utrinque circiter 9, arcuato-anastomosantibus, petiolo 1 5 ad 2 cm longo, fructibus axillaribus, solitariis, depresso-globosis, glabris, 5 ad 6 mm diametro, statu in sicco rugosis, umbonatis, pyrenis 7 vel 8, sepalis persistentibus triangulari-ovatis, acutis vel obtusis, 1 ad 1 4 mm longis, margine breviter ciliato-pubescenti

Sumatra, East Coast, Dĕlĕng Si Bajak, Karoland, *Bartlett 6504*, January 28, 1927

In the absence of complete material I cannot place this species other than as possibly belonging in the subsection Insignes, but it is to be noted that all species in this alliance are supposed to have 4-merous flowers, whereas the present species has 7-merous ones *Ilex Bartlettii* is characterized by its peculiarly toothed leaves, the teeth acuminate and incurved, and by its prominent nerves and reticulations, which are impressed above and elevated beneath

Ilex grandifolia, sp nov § Byronia (Tab XXV)

Arbor glabra, ramis teretibus, lenticellatis, cum ramulis ultimis in statu sicco atris vel atro-brunneis, ramulis circiter 2 mm crassis, foliis oblongis, coriaceis vel iunioribus submembranaceis, 16 ad 25 cm longis, 6 ad 8 cm latis, nitidis, pallide olivaceis vel brunneis, subtus pallidioribus, integris, basi late rotundatis, apice ut videtur acuminatis, nervis primariis utrinque 10 ad 13, supra haud perspicuis, subtus elevatis, curvatis, arcuato-anastomosantibus, reticulis primariis laxis, distinctis, elevatis, petiolo crasso, 1 ad 2 cm longo, cymis plerumque in axillis defoliatis, pedunculatis, multifloris, 3 ad 5 cm longis, laxis, pedunculo usque ad 3 5 cm longo, pedicellis 1 5 ad 2 5 mm longis, floribus parvis, sepalis 5, triangulari-ovatis, subacutis, circiter 1 mm longis, margine leviter ciliato, fructibus depresso-globosis, umbonatis, circiter 3 mm diametro, 14-locellatis

Sumatra, East Coast, Asahan, Adian Bolon, along the Toba trail north of the Asahan River, between Adian Langge and Si Martoloe, *Bartlett 7395*, April 21–25, 1927, Seriboe Dolok, Simeloengoen, *Yates 1584*, Tapianooli, Porsea to Toetoepan, *Yates 2301* (type), February 4, 1927

A species characterized by its large leaves and many-celled fruits belonging in the group with *Ilex cymosa* Blume and probably, among the described species, most closely allied to *Ilex macrophylla* Wall

CELASTRACEAE

Microtropis sumatrana, sp. nov. (Tab. XXVI.)

Arbor glabra, ramis teretibus, ramulis plus minusve compressis, 2 mm diametro, foliis chartaceis, pallidis, nitidis, ellipticis vel oblongo-ellipticis, 17 ad 25 cm longis, 8 ad 13 cm latis, breviter abrupteque acuminatis, basi acutis vel late acutis, nervis primariis utrinque circiter 9, distantibus, laxe arcuato-anastomosantibus, gracilibus, subtus elevatis, petiolo 1 ad 2 cm longo, stipulis rigidis, lineari-oblongis, circiter 7 cm longis, cymis breviter pedunculatis, axillaribus, 2 ad 2.5 cm longis; bracteis bracteolisque ovatis, obtusis 1 ad 1.5 mm longis, sepalis persistentibus, orbiculari-ovatis, rotundatis, *circiter 1.2 mm latis*, fructibus iunioribus rostratis, maturis ellipsoideis, 1 ad 1.2 cm longis, breviter apiculatis.

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 214* (type), *275*, February-March, 1928.

A species characterized by its large, abruptly rostrate-acuminate leaves and its ellipsoid apiculate fruits. The generic descriptions generally call for exstipulate leaves, in the terminal pair of leaves in most or all species the stipules are usually evident.

ICACINACEAE

Gomphandra subrostrata, sp. nov. (Tab. XXVII.)

Frutex vel arbor parva, ramis teretibus, glabris, ramulis 1.5 mm crassis, dense breviter fulvo-pubescentibus, foliis oblongis, chartaceis, fragilibus, siccitate olivaceis vel atris, subtus paulo pallidioribus, 15 ad 25 cm longis, 4.5 ad 8.5 cm latis, supra glabris vel iunioribus ad costam nervosque breviter pubescentibus, subtus ad costam nervosque breviter subferrugineo-pubescentibus, basi late acutis vel subrotundatis, apice longe tenuiterque acuminatis, nervis primariis utrinque circiter 8, ascendentibus, perspicuis, costa supra impressa, subtus elevata, petiolo 5 ad 8 mm longo, glabro, iuniore pubescenti, inflorescentiis axillaribus, brevibus, breviter pubescentibus, paucifloris, sub fructu vix 5 mm longis, fructibus glabris, oblongo-ovoideis, breviter crasse rostratis, 10 ad 12 mm longis.

Sumatra, East Coast, Damoeli, Koealoe, *Rahmat Si Toroes 1323*, September 13-14, 1928 (type), Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 252*, February-March, 1928.

A species characterized by its relatively large, prominently nerved, strongly acuminate leaves, the characteristic dense short indumentum on the younger parts, its very short few-flowered axillary inflorescences, and its distinctly but shortly rostrate fruits

Gomphandra Yatesii, sp nov (Tab XXVIII)

Frutex vel arbor parva, ramulis iunioribus inflorescentiisque exceptis glaber, ramis teretibus, ramulis ultimis circiter 1 mm crassis, breviter consperse pubescentibus, foliis oblongis vel oblongo-ellipticis, chartaceis vel submembranaceis, olivaceis, supra glabris, subtus paulo pallidioribus, glabris vel iunioribus ad costam obscure breviter pubescentibus, basi late acutis, nervis primariis utrinque circiter 8, subtus elevatis, distinctis, arcuato-anastomosantibus, reticulis obscuris, laxis, petiolo 6 ad 12 mm longo, glabro inflorescentiis solitariis, in axillis superioribus, cymosis, multifloris, longe graciliter pedunculatis, pedunculo usque ad 7 cm longo, ramis primariis circiter 4, patulis, subumbellatim dispositis, 1 ad 2 5 cm longis, plerumque trichotomis, breviter pubescentibus, floribus 5-meris, circiter 3 mm longis, in ramulis ultimis plus minusve umbellatim confertis, subsessilibus vel breviter pedicellatis, pedicellis vix 1 mm longis, dense breviter pubescentibus, calycibus glabris, circiter 1 mm diametro, truncatis vel obscurissime denticulatis, petalis 5, oblongis, acutis, 2 5 mm longis et 1 mm latis, glabris, staminibus 5, circiter 2 4 mm longis, filamentis deorsum glabris, infra antheras perspicue albido-barbatis, pilis debilibus, 1 ad 1 5 mm longis, ovario glabro

Sumatra, East Coast, Bandar Poeloeh and Masihi, Asahan, *Yates 2248, 2637* (type), February and August, 1927

A species in its slender elongated peduncles and in other characters approaching *Gomphandra gracilis* King of the Malay Peninsula, but with smaller, more numerously nerved leaves and broader inflorescences, the filament hairs not at all bulbous but somewhat crispate

Iodes Yatesii, sp nov

Frutex scandens, consperse breviter pubescens, ramis teretibus, glabris vel obscure pubescentibus, circiter 2 mm crassis, internodiis elongatis, usque ad 14 cm longis, foliis elliptico-ovatis, chartaceis, viridibus, 7 ad 12 cm longis, 3 ad 6 cm latis, basi rotundatis, apice distincte acutissime acuminatis, supra glabris, vel ad costam brevi-

ter pubescentibus, minute denseque nec profunde subfoveolatis, opacis vel subnitidis, subtus perspicue reticulatis, nervis reticulisque elevatis, disperse breviterque pubescentibus, nervis primariis utrinque circiter 5, elevatis, perspicuis, curvato-anastomosantibus, secundariis subaequaliter perspicuis, petiolo 5 ad 12 mm longo, breviter pubescenti, cirrhis usque ad 15 cm longis, disperse pubescentibus, inflorescentiis longe (ca 8 cm) pedunculatis, paucifloris, axillaribus, partibus iunioribus distincte breviter subferrugineo-pubescentibus, 2 ad 4 cm diametro, alabastris iunioribus globosis, sepalis petalisque 4, immaturis extus pubescentibus, fructibus oblongis, dense breviter ferrugineo-pubescentibus, 2 5 ad 3 cm longis, circiter 1 5 cm latis, sursum obscure compressis, deorsum inflatis, lateraliter obscure bicarinatis, grosse sulcato-reticulatis, obtusis, basi abrupte late rotundatis

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 1342* (type), *1591*, March and May, 1925

These specimens were originally referred to *Iodes reticulata* King, of the Malay Peninsula, to which it is manifestly allied in its 4-merous flowers It seems, however, not to be the same as King's species, lacking the broad lines of tomentum on the stems, the upper surface of the leaves not reticulate, the lower not with long soft hairs but with scattered, short, rather stiff ones, and differs further in its few-flowered small cymes, and in its fruits being broadly and abruptly rounded at the base, not narrowed below

Iodes floribunda, sp nov (Tab XXIX)

Frutex scandens, partibus iunioribus et foliis et inflorescentiis molliter subferrugineo-pubescentibus, ramis teretibus, circiter 3 mm crassis, obscure sulcatis, brevissime pubescentibus glabrescentibus, ramulis ultimis 2 mm crassis, haud sulcatis, dense molliter pubescentibus, foliis chartaceis vel subcoriaceis, elliptico-ovatis, pallide olivaceis, 7 ad 14 cm longis, 4 ad 7 cm latis, basi rotundatis, apice acutis vel breviter acute acuminatis, supra glabris vel ad costam pubescentibus, subtus subdense molliter pilosis, nervis primariis utrinque circiter 6, curvato-ascendentibus, anastomosantibus, subtus perspicuis, elevatis, reticulis distinctis, petiolo 1 ad 2 cm longo, dense pubescenti, cirrhis usque ad 15 cm longis, dense ferrugineo-pubescentibus, inflorescentiis terminalibus usque ad 50 cm longis, myrianthis, ramis primariis usque ad 20 cm longis, dense molliter pallide ferrugineo-pubescentibus, floribus in ramulis ultimis plus

minusve confertis, sessilibus vel brevissime pedicellatis, floribus ♂ 5-meris, circiter 2 5 mm longis, ciliatis, calycibus stellatis, 1 5 mm diametro, ciliatis, 5-lobatis, lobis lanceolatis, acuminatis, 0 5 mm longis, corollae tubo brevi, lobis lanceolatis, tenuiter acuminatis, ciliatis, 2 2 mm longis antheris 0 7 mm longis, floribus ♀ fructibusque ignotis

Sumatra, East Coast, Silo Maradja, Asahan, in the vicinity of Taloen Djoring, *Rahmat Si Toroes 77*, December, 1927

A species well characterized by its unusually large terminal, very many flowered inflorescences, its elongated primary inflorescence branches, its sessile or subsessile flowers more or less crowded toward the tips of the ultimate branchlets, and its lanceolate, slenderly acuminate petals Its alliance is with *Iodes ovalis* Blume

VITACEAE

Pterisanthes heterotricha, sp nov (Tab XXX)

Frutex scandens, ramis gracilibus, dense cinnamomeo-araneosis atque pilos longos simplices pallidos ferentibus, ramulis circiter 1 mm crassis, foliis 3-foliolatis, petiolis et petiolulis et foliolis subtus cinnamomeo-araneosis atque ad costam nervosque pilos longos pallidos simplices ferentibus, supra olivaceo-viridibus, consperse pallide ciliatis, costa cinnamomeo-araneosa, petiolo 6 ad 9 cm longo, petiolulis 1 ad 2 5 cm longis, foliolis membranaceis, perspicue acuminatis, 11 ad 15 cm longis, 3 ad 5 cm latis, medianis aequilateralibus, basi acutis, lateralibus perspicue inaequilateralibus, basi extus late rotundatis, intus acutis, margine distanter serrulato vel serrulato-dentato, nervis primariis utrinque 8 ad 10, gracilibus, distinctis, subascendentibus, receptaculis floriferis tenuiter pedunculatis, planis, circiter 5 cm longis et 2 cm latis, obtusis, basi valde inaequilateralibus, ad costam et marginem cinnamomeo-araneosis ceteroquin glabris, floribus immersis circiter 1 mm diametro, marginalibus paucis, pedicellatis, pedicellis cinnamomeo-araneosis, circiter 8 mm longis, pedunculo cinnamomeo-araneoso, circiter 4 cm longo

Sumatra, East Coast, near Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7597*, May 3, 1927

A species in the group with *Pterisanthes cissoides* Blume, strongly characterized by its indumentum, which consists of weak, easily

rubbed-off cobwebby cinnamomeous hairs and scattered pale simple ones, the latter being conspicuous on the upper surfaces of the leaflets, beneath on the midribs and lateral nerves, and on the petioles, petiolules, and branchlets

ELAEOCARPACEAE

Elaeocarpus stenophyllus, sp nov § Euelaeocarpus

Arbor magna partibus iunioribus inflorescentiisque exceptis glabra, ramis teretibus, glabris, nigris, lenticellatis, ramulis ultimis circiter 1 mm crassis, minute puberulis, foliis lanceolatis vel anguste lanceolatis, chartaceis vel subcoriaceis, fragilibus, 4 ad 9 cm longis, 8 ad 15 mm latis, tenuiter acuminatis, basi cuneatis, margine obscure crenato-dentato, iunioribus obscure consperse pilosis glabrescentibus, supra statu siccato nigris, nitidis, costa saepe albido-pilosa, subtus pallidioribus, brunneis, consperse atro-glandulosis, *nervis primariis utrinque 5 ad 7, gracilibus, obscuris, ascendentibus*, petiolo 6 ad 10 mm longo, obscure pubescenti, racemis paucis, axillaribus, gracilibus, paucifloris, 4 ad 6 cm longis, cinereo-pubescentibus, floribus parvis, pedicellis circiter 3 mm longis, sepalis oblongo-lanceolatis, acutis, extus pubescentibus, 3 mm longis, 1 2 mm latis, petalis quam sepalis paulo longioribus, glabris, usque ad medium laciniatis, laciniis circiter 25, filiformibus, staminibus circiter 20, antheris oblongis, obtusis, 1 5 mm longis, minute scaberulis, cellulis longioribus obscure breviter barbatis, filamentis 0 5 mm longis, ovario 3-loculari, pubescenti, stylis 1 5 mm longis, glabris, glandulis 5, pubescentibus, 0 5 mm diametro

Sumatra, East Coast, near the Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7022*, March 21, 1927

A species characterized by its narrow Salix-like leaves, small flowers, and entirely glabrous petals It seems to resemble *Elaeocarpus salicifolius* King, of the Malay Peninsula, but that species has petals with but about 8 fimbriae which are pubescent inside

STERCULIACEAE

Sterculia cauliflora, sp nov § Eusterculia

Frutex simplex 2 ad 3 m altus, caulibus circiter 5 cm diametro foliis permagnis, oblongo-ellipticis vel late oblongo-oblanceolatis

50 ad 65 cm longis, 20 ad 30 cm latis, chartaceis, viridibus, subtus paulo pallidioribus, supra glabris, subtus parce stellato-pubescentibus, inter reticulis dense griseo-puberulis, apice longe acuminatis, basi rotundatis, 6 ad 8 cm latis, leviter peltatis vel anguste cordatis, nervis primariis utrinque 12 ad 17, perspicuis, circiter ad marginem arcuato-anastomosantibus, costa subtus valde elevata, petiolo 15 ad 26 cm longo, inflorescentiis caulinis, racemosis, 10 ad 13 cm longis, in ramulis vel tuberculis brevibus lateralibus fasciculatis, dense breviter stellato-pubescentibus, indumento ferrugineo vel castaneo, floribus albidis vel rubescentibus, saltem 16 mm longis, extus dense breviter stellato-pubescentibus, intus perspicue disperse ciliato-hirsutis, tubo lato, circiter 3 ad 4 mm longo, lobis anguste lanceolatis, arcuatis, cohaerentibus, circiter 15 mm longis, deorsum 2 5 mm latis, intus consperse albido-hirsutis, staminibus vel staminodiis 10, sessilibus vel subsessilibus, ovario dense ferrugineo-hirsuto, stylis recurvatis, 3 mm longis, perspicue hirsutis, floribus ♂ atque ♀ simillimis, antheris 10, in capitulis globosis dispositis, androphoro glabro, vix 1 mm longo, folliculis plerumque 5, oblongo-lanceolatis, sessilibus vel brevissime pedicellatis, 10 ad 15 cm longis, perspicue acuminatis, pericarpio coriaceo, intus glabro, extus dense brevissime ferrugineo-puberulo, seminibus circiter 10, ellipsoideis, glabris, nigris, circiter 1 5 cm longis, pedunculo crasso

Sumatra, East Coast, Běrastagi, Karoland, *Yates 1455* (type), *1964*, the former in flower, April 5, 1925, the latter in fruit, March 31, 1926, in forests, altitude about 1500 m

A species strongly characterized by its long petioles, very large leaves, and cauline inflorescences *Sterculia megistophylla* Ridl from Sungei Kumbang is a large tree with broadly subcordate peltate leaves up to 45 cm long and 20 cm wide, with paniculate inflorescences 25 cm long, and except in leaf size does not appear to resemble the present species

Sterculia patentinervia, sp nov § Eusterculia (Tab XXXI)

Ut videtur frutex parvus, ramulis iunioribus et petiolis et inflorescentiis exceptis glaber, ramis teretibus, brunneis, rugosis, glabris, ramulis ultimis rugosis, circiter 3 mm crassis, dense rufo-pubescentibus, pilis brevibus, stellatis, foliis chartaceis, integris, oblongis, glabris, 15 ad 28 cm longis, 4 5 ad 8 cm latis, pallide olivaceis, utrinque concoloribus nitidisque, basi obtusis vel late acutis,

apice perspicue obtuseque acuminatis, acuminibus 1 ad 1 5 cm longis, nervis primariis utrinque circiter 19, patulis, distinctis, arcuato-anastomosantibus, costa utrinque elevata, petiolo 1 5 ad 6 cm longo, consperse stellato-pubescenti, glabrescenti, stipulis lanceolatis, acuminatis, pubescentibus, caducis, usque ad 4 mm longis, inflorescentiis lateralibus, solitariis, anguste paniculatis, usque ad 18 cm longis et 5 cm latis, dense stellato-pubescentibus, pilis subferrugineis, brevibus, ramis primariis gracilibus, distantibus, patulis, usque ad 2 5 cm longis, floribus ♂ 8 ad 9 mm longis, pedicellis gracilibus, circiter 3 mm longis, calycis tubo cuneato, circiter 3 mm longo et 4 mm lato, leviter pubescenti, lobis 5, lineari-lanceolatis, 6 mm longis, arcuatis, cohaerentibus, ciliato-hirsutis, androphoro glabro, circiter 1 mm longo, capitulis globosis, 1 mm diametro, antheris 10, floribus fructibusque ignotis

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 312*, February–March, 1928

A species characterized by its oblong, glabrous, shining, many-nerved leaves, the nerves conspicuous, spreading, its diverse petioles varying in length from 1 5 to 6 cm , and by its narrow, lateral panicles

Sterculia urophylla, sp nov § Eusterculia (Tab XXXII)

Frutex vel arbor parva, ramis teretibus, glabris, gracilibus, pallidis, ramulis circiter 1 mm crassis, rubro-brunneis, junioribus plus minusve hirsutis, foliis lanceolatis vel oblongo-lanceolatis, integris, chartaceis vel membranaceis, 7 ad 13 cm longis, 2 ad 3 5 cm latis, graciliter petiolatis, basi obtusis vel late acutis, apice tenuiter longissime caudato-acuminatis, acuminibus plerumque falcatis, supra glabris, pallide viridibus vel brunneis, subtus praesertim ad costam nervosque consperse stellato-pubescentibus, nervis primariis utrinque 6, gracilibus, distinctis, curvato-ascendentibus, arcuato-anastomosantibus, petiolo 1 ad 2 5 cm longo, plus minusve stellato-hirsuto, stipulis caducis, lineari-lanceolatis, hirsutis, circiter 2 mm longis, inflorescentiis laxis, ut videtur pendulis, racemosis vel depauperato-paniculatis, usque ad 15 cm longis, gracilibus, consperse subferrugineo-hirsutis, pedicellis gracilibus, hirsutis, usque ad 1 5 cm longis, floribus ♂ circiter 2 cm longis, tubo cylindrico, 10 mm longo, extus consperse hirsuto, circiter 2 mm diametro, lobis 5, arcuatis, haud cohaerentibus, lineari-lanceolatis, 10 mm longis, basi 2 mm latis, ciliato-hirsutis, pilis albidis, rigidis, margine

revoluto, androphoro glabro, vix 1 mm longo, capitulis globosis, 1 mm diametro, antheris circiter 8, floribus ♀ fructibusque ignotis

Sumatra, East Coast, near Marbau, Bilah, Bilah Pertama (Parbasiran), *Rahmat Si Toroes 280, 308* (type), February–March, 1928, Bandar Poeloeh, Asahan, *Yates 2142*

A species strikingly similar to *Sterculia gracilis* Korth of Borneo, and *S gracilioides* Koord & Val of Sumatra, differing from the former in the indumentum and in its more numerously nerved leaves, and from the latter in the same characters and, further, in its greatly elongated calyx tubes and long and slenderly pediceled flowers

VIOLACEAE

Rinorea floribunda (King), comb nov

Alsodeia floribunda King in *Journ As Soc Bengal*, 58 (2) 406 1889 (*Mater Fl. Malay Penin*, 1 50 1889), Brühl and King in *Ann Bot Gard Calcutta*, 5 (2) 125, Pl 143B 1896, Ridl, *Fl Malay Penin* 1 132 1922

Sumatra, East Coast, Asahan, *Yates, 1338* Malay Peninsula

The original description was based in part on specimens from Perak, in part on *Forbes 1719* and *Beccari 683*, from Sumatra

Rinorea Hamelii, sp nov § Prosthesia

Arbor parva, partibus iunioribus inflorescentiisque parcissime consperse breviter pubescentibus exceptis glabra, ramis teretibus, pallidis, ramulis iunioribus sulcatis, circiter 1 mm crassis, plerumque olivaceis, foliis oblongis, 4 ad 8 cm latis, supra olivaceo-viridibus, nitidis, subtus pallidis, utrinque glabris vel iunioribus subtus obscure pubescentibus, integris vel distanter obscure apiculato-serrulatis, utrinque subaequaliter angustatis, basi late acutis, paulo inaequilateralibus, apice distincte acuminatis, nervis primariis utrinque 13 ad 15, subtus perspicuis, elevatis, curvato-anastomosantibus, reticulis primariis subparallelis, stipulis deciduis, lineari-lanceolatis, acuminatis, 4 mm longis, petiolo 1 ad 1 5 cm longo, inflorescentiis axillaribus, depauperato-cymosis, paucifloris, rhachibus vix 3 mm longis, leviter pubescentibus, pedicellis 5 ad 10 mm longis, sepalis orbiculari-ovatis, concavis, extus parcissime breviter pubescentibus, rotundatis, 4 mm longis, subcoriaceis, interioribus paulo tenuioribus, petalis membranaceis, glabris, oblongo-ovatis vel oblongo-ellipticis, obtusis, 5 ad 5 5 mm longis, 2 5 ad 3 mm latis, filamentis

glabris, partibus liberis latis, 0 5 mm longis, antheris 2 mm longis, cellulis apiculatis, extremitatibus oblongis, acutis, 0 5 mm longis, appendicibus membranaceis, orbiculari-ovatis, rotundatis, 1 mm diametro, ovario oblongo-ovoideo, leviter ciliato-pubescenti, stylis glabris, 2 5 mm longis

Sumatra, East Coast, Si Toenggir, 9 kilometers from Damoeli, Kocaloc, *Rahmat Si Toroes 1411* (type), September 20, 1928, between Bangoen Dolok and Dolok Maradja, Asahan, *Rahmat Si Toroes 1208*, September 2, 1928, Bandar Poeloeh, Asahan, *Yates 1745*

A species apparently allied to *Rinorea Kunstleriana* (King) Taub, but with distinctly different inflorescences which are depauperate-cymose, the non-fasciculate flowers, furthermore, differing in numerous details

Rinorea sumatrana, sp nov § Pentaloba

Arbor parva, inflorescentiis parce pubescentibus exceptis glabra, ramis ramulisque teretibus, ramulis circiter 2 mm crassis, foliis oblongis, chartaceis vel subcoriaceis, 15 ad 25 cm longis, 5 ad 8 cm latis, utrinque subaequaliter angustatis, basi acutis, apice acuminatis, supra pallide viridibus, subtus paulo pallidioribus, margine integro vel obscure crenulato-serrato, dentibus glandulosis, nervis primariis utrinque circiter 12, subascendentibus, supra impressis, subtus elevatis, perspicuis, arcuato-anastomosantibus, reticulis primariis gracilibus, subparallelis, petiolo 6 ad 11 mm longo, stipulis caducis, lanceolatis, acuminatis, extus plus minusve pubescentibus 7 mm longis, cymis axillaribus, solitariis, breviter pedunculatis, plus minusve consperse cinereo-pubescentibus, 1 5 ad 2 cm longis, multifloris, bracteis bracteolisque triangulari-ovatis, acutis, extus cinereo-pubescentibus, 2 mm longis, pedicellis circiter 2 mm longis, sepalis orbiculari-ovatis, concavis, 3 ad 3 5 mm longis, rotundatis, extus consperse adpresse breviter pubescentibus, oblongo-ellipticis, obtusis, extus in partibus medianis breviter adpresse pubescentibus, 4 mm longis, 2 mm latis, filamentis glabris, 1 5 mm longis, antheris 1 mm longis, cellulis obtusis, appendicibus membranaceis, rotundatis, 0 5 mm diametro, ovario glabro, stylis 2 mm longis, capsulis oblongo-ellipsoideis, 3 cm longis, glabris, rotundato-triangulatis, brevissime apiculatis

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 1640*

(type), Marbau, Bilah, near Bilah Pertama (Parbasiran) *Rahmat Si Toroes 339*, February March, 1928

A species resembling **Rinorea condensa** (King), comb nov (*Alsodeia condensa* King, in *Journ As Soc Bengal*, 58 (2) 405 1889, Brühl and King in *Ann Bot Gard Calcutta*, 5 (2) 126, Pl 145 1896) of the Malay Peninsula, but with very much larger, differently shaped fruits

Rinorea Yatesii, sp nov § Pentaloba

Frutex vel arbor parva, ramulis et petiolis et inflorescentiis breviter consperse pubescentibus exceptis glabri, ramulis plus minusve compressis vel sulcatis, circiter 1 mm diametro foliis membranaceis, late oblongo-oblanceolatis, olivaceis, nitidis, subtus paulo pallidioribus, glabris vel iunioribus subtus ad costam nervosque parce pubescentibus, 14 ad 18 cm longis, 4 ad 7 cm latis, apice perspicue subabrupte acuminatis, basi cuneatis, margine serrato-dentato, dentibus incurvo-apiculatis, nervis primariis utrinque circiter 8, perspicuis, curvatis, arcuato-anastomosantibus, reticulis laxis, haud parallelis, petiolo 1 ad 1 3 cm longo, breviter cinereo-pubescenti, inflorescentiis axillaribus, paucifloris, inferioribus racemosis, solitariis vel binis, rhachibus usque ad 5 mm longis, cicatricibus multis confertis perspicuis instructis, floribus seriatim deciduis, superioribus fasciculatis, pedicellis glabris vel parcissime pubescentibus, circiter 3 mm longis, bracteolis minutis orbiculari-ovatis, rotundatis, leviter pubescentibus, vix 1 mm longis, sepalis concavis, subcoriaceis, extus parcissime consperse pubescentibus, late ovatis, acutis vel obtusis, 2 8 mm longis, petalis oblongo-ovatis, obtusis, glabris vel margine minute ciliato, 3 mm longis, filamentis coniunctis glabris, antheris sessilibus vel subsessilibus, oblongo-ovatis, 2 mm longis, cellulis 1 2 mm longis, obtusis, appendicibus membranaceis, ovatis, perspicue acuminatis 1 5 mm longis ovario hirsuto, stylis fusiformibus, glabris, 2 mm longis

Sumatra, East Coast, Goerach Batoe, Asahan, *Yates 1627*, June 21, 1925

A species characterized by its thin, shining leaves and its few-flowered axillary inflorescences, which are at first strictly fasciculate, but the rachis, which is supplied with numerous crowded, conspicuous pedicel scars, ultimately extending to at least 5 mm in length, the flowers falling serially, so that each rachis bears but one or few

flowers at any one time It seems to be allied to *Rinorea Wrayi* (King) Taub of the Malay Peninsula

FLACOURTIACEAE

Casearia multipunctata, sp nov

Frutex vel arbor parva, ramis vetustioribus glabris, iunioribus pubescentibus, ramulis ultimis circiter 1 mm crassis, breviter sordide villosis, foliis membranaceis vel chartaceis, oblongis vel oblongo-ellipticis, 6 ad 10 cm longis, 2 5 ad 4 cm latis, utrinque subaequaliter angustatis, apice acutis vel breviter acuminatis, basi acutis, vix inaequilateralibus, supra olivaceo-brunneis, glabris, multipunctatis, glandulis rotundatis elongatisque intermixtis, margine deorsum integro sursum minute distanter denticulato, nervis primariis utrinque 4 ad 7, curvato-ascendentibus, arcuato-anastomosantibus, subtus elevatis, perspicuis, petiolo breviter villoso, 4 ad 7 mm longo, fructibus axillaribus, solitariis vel fasciculatis, pedicellis circiter 7 mm longis, sursum paulo incrassatis, leviter pubescentibus, sepalis persistentibus oblongo-ovatis, obtusis, extus consperse pubescentibus, circiter 1 5 mm longis, fructibus ellipsoideis, glabris, circiter 7 mm longis

Sumatra, East Coast, Goerach Batoe, Asahan, *Yates 1302*, February 1, 1925

A species allied to *Casearia Lobbiana* Turcz and *C velutina* Blume, differing from the former particularly in its serrulate, not entire, leaves and its ellipsoid, not subglobose, fruits, and from the latter in its equilateral leaves, Blume's species having leaves with their bases acute on one side and rounded to cordate on the other side

Hydnocarpus Yatesii Merr , *Philip Journ Sci* , 20 402–403 1926

Arbor, partibus iunioribus inflorescentiisque plus minusve breviter subferrugineo-pubescentibus, ramis teretibus, glabris, ramulis ultimis 1 ad 1 5 mm crassis, breviter pubescentibus, foliis subcoriaceis, oblongis, integris, 7 ad 17 cm longis, 3 ad 7 cm latis, rectis vel superioribus plus minusve falcatis, subabrupte perspicueque acuminatis, basi late acutis, distincte inaequilateralibus, nervis primariis utrinque 7 ad 9, curvato-ascendentibus, anastomosantibus, subtus elevatis, perspicuis, reticulis primariis gracilibus, subparal-

lelis, iunioribus subtus, praesertim ad costam nervosque, breviter consperse pubescentibus, vetustioribus glabrescentibus, petiolo 8 ad 14 mm longo, pubescenti, stipulis lanceolatis, acuminatis, pubescentibus, 8 ad 10 mm longis, deciduis, inflorescentiis ♂ axillaribus, solitariis, breviter (5 ad 8 mm) pedunculatis, imprimis depauperato-cymosis, paucifloris, mox in ramos paucos (2 ad 4) curvatos crassos usque ad 7 mm longos productis, floribus seriatim caducis, cicatrices multas confertas biseriatas relinquentibus, pedicellis breviter ferrugineo-pubescentibus, usque ad 4 mm longis, floribus ♂ parvis, 5-meris, seriatim caducis, sepalis 5, extus breviter ferrugineo-pubescentibus, orbiculari-ovatis, concavis, binis exterioribus minoribus, 1 5 ad 2 mm latis, interioribus maioribus, tenuioribus, 3 mm latis, petalis 5, membranaceis, obovatis vel orbiculari-obovatis, late rotundatis, concavis, extus consperse subferrugineo-pubescentibus, sepala maiora aequantibus, margine ciliato, squamis incrassatis, orbiculari-obovatis, utrinque pubescentibus, 1 5 mm latis, staminibus 5, filamentis deorsum incrassatis, 1 5 mm longis, antheris reniformibus, 0 5 mm longis, 0 7 mm latis, floribus ♀ ignotis, fructibus immaturis oblongo-cylindricis, saltem 8 cm longis et 4 cm diametro, pericarpio circiter 6 mm crasso, extus glabro, verruculoso, seminibus numerosis

Sumatra, East Coast, Goerach Batoe, Asahan, *Yates 1210* (type), *1661*, *1752*, November, 1924, and July, 1925, Silo Maradja, *Bartlett 8439*, *8713*, June, 1927

The material here referred to *Hydnocarpus Yatesii* clearly represents a species remote from any of the species of the Malay Archipelago considered by Van Slooten in 1925 It seems to be allied to *Hydnocarpus cucurbitina* King, of the Malay Peninsula, which, to judge from King's illustration, *Ann Bot Gard Calcutta*, 5 (2) 129, Pl 149 1896, has much the same type of staminate inflorescences, but which has glabrous petals, the scales nearly as large as the petals, and minutely tomentose, not glabrous, 1- or 2-seeded fruits

MELASTOMATACEAE

Anplectrum Yatesii, sp nov

Frutex scandens, ramis ramulisque teretibus, ramis glabris, ramulis 2 ad 2 5 mm crassis, dense pallide adpresse stellato-puberulis, indumento deciduo, foliis subcoriaceis, oblongo-ovatis, subabrupte

tenuiter caudato-acuminatis, basi late rotundatis vel leviter cordatis, 5-nervius, circiter 12 cm longis et 5 cm latis, supra viridibus, glabris, subtus pallidis vel pallide brunneis, dense adpresse molliter stellato-pubescentibus, petiolo 1 ad 1 3 cm longo, dense pubescenti, inflorescentiis axillaribus, terminalibusque, dense pallide stellato-pubescentibus, usque ad 15 cm longis, ramis inferioribus circiter 7 cm longis, floribus 4-meris, in ramulis ultimis ternatim dispositis, pedicellis 3 ad 6 mm longis, calyce circiter 7 mm longo, decidue stellato-pubescenti, basi acuto, sursum ampliato, apice circiter 6 mm diametro, late 4-dentato, dentibus circiter 4 mm latis et 1 5 mm longis, petalis 4, ellipticis, obtusis, 10 mm longis et 7 mm latis, staminibus 8, 4 maioribus filamentis 4 5 mm longis, antheris lanceolatis, acuminatis, 7 mm longis, connectivo dorsaliter appendiculato, appendicibus tenuibus, lanceolatis, acuminatis, 3 mm longis, basi sagittatis, lobis basalibus lanceolatis, acuminatis, 1 mm longis

Sumatra, East Coast, Karoland, Běrastagi, *Yates 2012*, March 12, 1926

This was originally referred to *Dissochaeta appendiculata* Blume, which it superficially resembles An examination of the flowers indicates Anplectrum rather than Dissochaeta, and a species apparently allied to *Anplectrum nodosum* Triana The indumentum, however, is composed of short, appressed, stellate, pale hairs, and is not at all furfuraceous

Oxyspora sumatrana, sp nov

Frutex erectus ramis et foliis (subtus) et inflorescentiis perspicue dense hirsutis, pilis breviter ciliatis Ramis teretibus, ultimis circiter 5 mm crassis, densissime hirsutis, foliis oppositis, paribus paulo inaequalibus, chartaceis vel subcoriaceis, ellipticis vel oblongo-ellipticis, breviter acuminatis, basi rotundatis, leviter cordatis, 7-nerviis, 15 ad 27 cm longis, 8 ad 11 cm latis, integris, supra in statu sicco atris, nitidis, glabris vel praesertim ad costam nervosque leviter pubescentibus, subtus pallidioribus, nervis elevatis, nervulis transversalibus subparallelis, perspicuis, petiolo 5 ad 11 cm longo, densissime brunneo-hirsuto, paniculis terminalibus, pedunculatis, dense hirsutis, multifloris, usque ad 30 cm longis, ramis inferioribus sub anthesin circiter 10 cm longis, fructiferis 20 cm longis, floribus 4-meris, roseis, breviter pedicellatis, bracteolis lineari-lanceolatis, hirsutis, usque ad 4 mm longis, deciduis, calycis tubo 6 ad 8 mm

longo, clavato, hirsuto, sursum 3 ad 4 mm diametro, lobis 4, lanceolatis, acuminatis 1 5 mm longis, petalis 4, late ovatis, abrupte acuminatis, 4 mm longis, staminibus 8, inaequalibus, maioribus filamentis 7 mm, antheris lineari-lanceolatis, acuminatis, 10 mm longis, basi rotundatis, minoribus filamentis 4 mm longis, antheris lanceolatis, 6 mm longis, convectivo haud appendiculato vel calcarato

Sumatra, East Coast, Toetoepan to Adian Langge, Asahan, *Yates 2353* (type), Tapianoeli, between Maranti and Sawah Sa Batoe Roewan, Habinsaran, *Bartlett 7851*, May, 1927

The anther connectives are neither appendaged nor spurred, and the species might be placed in the section Euoxyspora, with *O macrophylla* Triana, although the bases of the larger anthers are not lobed, or in the section Allosygia, with *O cernua* Hook f & Th It is apparently not allied to any previously described species

ARALIACEAE

Schefflera Bartlettii, sp nov § Euschefflera, Heptapleurum (Tab XXXIII)

Frutex epiphyticus, partibus iunioribus et inflorescentiis exceptis glaber, ramis ramulisque glabris, pallidis, plus minusve rugosis, ultimis circiter 3 mm crassis, foliis simplicibus, chartaceis, pallidis, nitidis, glabris, integris, oblongo-ovatis vel oblongo-ellipticis, 15 ad 25 cm longis, 4 5 ad 9 cm latis, tenuiter caudato-acuminatis, basi late acutis vel subrotundatis, nervis utrinque circiter 7, arcuato-anastomosantibus, subtus elevatis, reticulis laxis, distinctis, petiolo 2 5 ad 5 cm longo, stipulis lanceolatis, acuminatis, circiter 1 cm longis, cinereo-furfuraceis, inflorescentiis terminalibus, gracilibus, pedunculatis, usque ad 25 cm longis, decidue pallide subfurfuraceo-pubescentibus, umbellulis 10- vel 20-floris, racemose dispositis, pedunculis gracilibus, 1 5 ad 1 8 cm longis, pedicellis 2 ad 4 mm longis, floribus 5-meris, calycibus truncatis, petalis oblongo-ovatis, acutis, 1 5 mm longis, staminibus 5, filamentis usque ad 4 mm longis

Sumatra, East Coast, Membang Moeda, Koealoe, *Rahmat Si Toroes 1287* (type), September 7, 1928, Aek na Gerger, between Djoema Tombak and Taratak, Tanah Djawa, Simeloengoen, *Bartlett 8240*, June 7–8, 1927, *Bartlett 8267*, from the same locality, also probably belongs here

This simple-leaved form is distinguished not only by its vegeta-

tive characters, but also by its terminal slender inflorescences, the slenderly peduncled umbels being racemosely arranged along the main rachis

Schefflera multifoliolata, sp nov § Euschefflera, Heptapleurum

Frutex scandens, subglaber, ramulis teretibus, sulcatis, 5 mm crassis, decidue breviter stellato-pubescentibus, foliis saltem 50 cm longis, 5-digitatim decompositis, petiolo circiter 17 cm longo, foliolis numerosissimis, parvis, integris, in divisionibus ultimis palmatim 3-foliolatis vel pinnatim 5-foliolatis dispositis, foliolis chartaceis, viridibus, glabris, lanceolatis vel oblongo-lanceolatis, 3 ad 7 cm longis, 1 2 ad 2 cm latis, caudato-acuminatis, plerumque falcatis, basi plus minusve inaequilateralibus, acutis, nervis primariis utrinque circiter 7, reticulis distinctis, petiolulis 1 ad 10 mm longis, vel foliolis lateralibus plerumque sessilibus, paniculis terminalibus, amplis, laxis, primo plus minusve breviter stellato-pubescentibus, glabrescentibus, saltem 40 cm longis, ramis primariis paucis, distantibus, patulis, racemose dispositis, inferioribus usque ad 30 cm longis, umbellulis in ramis primariis racemose dispositis, graciliter pedunculatis, distantibus, circiter 10-floris, pedunculis 1 ad 1 5 cm longis, pedicellis 5 ad 6 mm longis, floribus parvis, 5-meris, petalis triangulari-ovatis, acutis, 2 mm longis

Sumatra, East Coast, Karoland, Mount Sibayak, *Yates 1970* (type), March 5, 1926, altitude about 1800 m

A characteristic species because of its digitately decompound leaves, numerous small, caudate-acuminate leaflets, and ample lax inflorescences with small 5-merous flowers It belongs in the small group with decompound leaves characterized by *Schefflera heterophylla* Harms and *S biternata* Harms, and the duplicates were distributed under the former name It is not closely allied to either

Schefflera Yatesii, sp nov § Euschefflera, Heptapleurum

Ut videtur frutex scandens, ramis glabris, internodiis elongatis, ramulis ultimis circiter 6 mm diametro, longitudinaliter rugoso-sulcatis, junioribus caduce stellato-pubescentibus, foliis longe (35 ad 50 cm) petiolatis, palmatim 7- vel 9-foliolatis, petiolo decidue breviter stellato-pubescenti, glabrescenti, petiolulis 2 ad 8 cm longis, foliolis oblongis vel oblongo-ellipticis, integris, chartaceis, pallide olivaceis, 15 ad 25 cm longis, 5 ad 9 cm longis, tenuiter subcaudato-

acuminatis, basi acutis vel obtusis, supra glabris, subtus consperse deciduo breviter stellato-pubescentibus, glabrescentibus, nervis primariis utrinque 5 ad 7, distantibus, arcuato-anastomosantibus, subtus elevatis, perspicuis, reticulis laxis, inflorescentiis terminalibus, solitariis vel binis, circiter 30 cm longis, umbellulis 5- vel 10-floris, breviter (2 ad 8 mm) pedunculatis, secus rhachin racemose dispositis, plus minusve cinereo-pubescentibus, indumento stellato-furfuraceo, fructibus oblongo-ellipsoideis, 7 mm longis, 5-locellatis, longitudinaliter 5-angulatis, 5-sulcatis

Sumatra, East Coast, Goerach Batoe, Asahan, *Yates 1370* (type), March 8, 1925, Silo Maradja, Asahan, *Bartlett 7189*, April, 1927, Bosar Si Pinggan, Asahan, *Hamel 1181*, September 2, 1928

The species is characterized by its long-petioled, palmately 7- or 9-foliolate leaves, the subcaudate-acuminate leaflets with prominent nerves, its scant deciduous indumentum of short stellate hairs, and its terminal inflorescences, the short-peduncled umbels being racemosely arranged along the main rachis The flowers are 5-merous

CLETHRACEAE

Clethra longipedicellata, sp nov

Frutex vel arbor parva, ramulis et inflorescentiis et foliis (subtus) dense molliter subferrugineo-tomentosis, ramis ramulisque teretibus, 2 ad 3 mm crassis, foliis coriaceis, oblongo-ellipticis, 8 ad 15 cm longis, 4 ad 7 cm latis, acutis vel breviter acuminatis, rariter subrotundato-obtusis, basi acutis, supra glabris vel ad costam nervosque in foliis iunioribus plus minusve ferrugineo-pubescentibus, brunneo-olivaceis, subtus pallidioribus, praesertim ad costam nervosque dense molliter ferrugineo-tomentosis, margine distincte serrato-dentato, in parte inferiore integro, dentibus breviter apiculatis, nervis primariis utrinque 10 ad 12, distinctis, supra paulo impressis, subtus elevatis, petiolo 1 ad 2 cm longo, dense ferrugineo-tomentoso, racemis terminalibus, circiter 30 cm longis, multifloris, dense ferrugineo-tomentosis, bracteolis deciduis, lineari-lanceolatis, acuminatis, pubescentibus, usque ad 2 5 cm longis, pedicellis 1 5 ad 2 cm longis, sepalis elliptico-ovatis, acutis vel breviter acuminatis, circiter 8 mm longis et 4 mm latis, extus dense ferrugineo-pubescentibus, pilis brevibus cum elongatis intermixtis, petalis glabris, subellipticis, concavis, truncatis vel truncato-rotundatis, 9 mm

longis, 6 mm latis, filamentis circiter 7 mm longis, curvatis, incrassatis, supra angustatis, dense longeque ferrugineo-hirsutis, pilis rectis, usque ad 2 5 mm longis, antheris circiter 4 mm longis, basi breviter acuminatis, lobis apicalibus similiter acuminatis, ovario ovoideo, 4 mm diametro, dense hirsuto, stylis glabris, 8 mm longis

Sumatra, East Coast, along the Toba trail north of the Asahan River, between Adian Langge and Si Martoloe, Asahan, *Bartlett 7394*, April 21–25, 1927

A species distinguished by its marked indumentum, its large many-flowered racemes, its long pedicels, and its large flowers

Clethra pubifolia, sp nov

Frutex vel arbor parva, ramis ramulisque breviter subcastaneo-pubescentibus, ramis vetustioribus glabris, ramulis ultimis teretibus, circiter 2 mm crassis, foliis oblongo-lanceolatis, subcoriaceis, 7 ad 13 cm longis, 2 5 ad 4 5 cm latis, utrinque subaequaliter angustatis, basi acutis, apice breviter acute acuminatis, supra glabris, castaneo-olivaceis, subtus pallidioribus, breviter subferrugineo-pubescentibus, nervis primariis utrinque circiter 12, distinctis, supra paulo impressis, subtus elevatis, curvatis, secundariis distinctis, margine deorsum integro, sursum distincte distanter breviter dentato vel serrulato-dentato, petiolo 1 ad 2 cm longo, breviter subcastaneo-pubescenti, racemis axillaribus terminalibusque, gracilibus, usque ad 30 cm longis, dense breviter pubescentibus, multifloris, bracteolis subpersistentibus, lineari-lanceolatis, pubescentibus, acuminatis, usque ad 1 5 cm longis, pedicellis 5 ad 10 mm longis, breviter pubescentibus, sepalis oblongo-ovatis, acutis, dense breviter pubescentibus, interdum pilis paucis longioribus intermixtis, circiter 5 mm longis, petalis oblongo-obovatis, glabris, truncatis vel retusis, circiter 7 mm longis et 4 mm latis, filamentis 4 5 mm longis, curvatis, longe hirsutis, sursum angustatis, antheris 2 5 mm longis, basi breviter apiculato-acuminatis, lobis apicalibus similiter acuminatis, ovario depresso-globoso, 2 5 mm diametro, dense hirsuto, stylis glabris, 6 mm longis, capsulis depresso-globosis, hirsutis, circiter 5 mm diametro

Sumatra, East Coast, Simeloengoen, Siantar to Parapat, *Yates 1285* (type), January 25, 1925, Asahan, Adian Langge, *Yates 2348*, April 4, 1927, Tapianoeli, on the Tor Dabolon, near Panapparan, Habinsaran, *Bartlett 7890*, May 16, 1927

Some of these specimens were first identified as representing *Clethra pulcherrima* Ridl , but they all differ markedly from Ridley's species, which may prove not to be specifically distinct from *Clethra sumatrana* J J Smith, in the conspicuous short indumentum, particularly on the younger branchlets and on the lower surfaces of the leaves Ridley's species is clearly represented by *Yates 1518*, from Sibayak, the type locality, a plant with glabrous leaves *Bartlett 8312*, from Dolok Batoe Merdingding, Tanah Djawa, Simeloengoen, altitude 1280 m , may represent *Clethra pulcherrima* Ridl or *C sumatrana* J J Sm , the type of the latter being from Toba, near Bonan Dolok

ERICACEAE

Diplycosia sumatrensis, sp nov

Frutex ut videtur scandens, ramis pallidis, glabris, ramulis ultimis circiter 1 5 mm crassis, consperse hirsutis, foliis coriaceis, ellipticis, supra pallidis, nitidis, glabris, subtus, praesertim ad costam, conspersissime hirsutis, glabrescentibus, brunneis, 3 ad 4 cm longis, 1 3 ad 2 2 cm latis, breviter apiculato-acuminatis, basi acutis, basi trinerviis, nervis lateralibus transversalibusque supra distincte impressis, subtus obsoletis vel subobsoletis, transversalibus utrinque 4 ad 6 cum lateralibus anastomosantibus, petiolo glabro vel obscure hirsuto, circiter 4 mm longo, floribus axillaribus, plerumque 2 vel 3, rariter solitariis, albidis, circiter 9 mm longis, pedicellis circiter 1 cm longis, castaneo-hirsutis, basi bracteis paucis ovatis acuminatis 2 mm longis subtentis, apice bracteolas binas late ovatas acuminatas carinatas 3 mm longas ferentibus, calycis lobis ovato-lanceolatis, perspicue acuminatis, 4 mm longis, extus margineque disperse hirsutis, corollae tubo glabro, 7 5 mm longo, ovoideo, lobis recurvatis, oblongo-ovatis, obtusis, 1 5 mm longis, staminibus 10, filamentis glabris, 4 mm longis, antheris lanceolatis, acuminatis, 3 mm longis, ovario obovoideo-globoso, disperse ciliato, stylis glabris

Sumatra, West Coast, Mount Singgalan, *Yates 2452*, April 19, 1927, in forests at an altitude of about 2250 m

A species characterized by its large flowers and its scattered brown to castaneous hairs The flowers are normally 2 or 3 in a fascicle, sometimes solitary The slender nerves are distinctly impressed on the upper surface, but are usually not evident on the lower surface

Diplycosia Bartlettii, sp nov

Frutex, ut videtur epiphyticus, glaber, ramis atro-brunneis ramulis pallidis vel brunneis, circiter 2 mm crassis, foliis coriaceis, rigidis, brunneis, nitidis, acuminatis, basi acutis, 5 ad 9 cm longis, 2 ad 3 5 cm latis, margine revoluto, penninervus vel interdum etiam obscure triplinerviis, subtus consperse punctatis, nervis lateralibus utrinque plerumque 10, haud perspicuis, supra vix impressis, petiolo 6 ad 10 mm longo, floribus numerosis, axillaribus, fasciculatis, pedicellis glabris, circiter 5 mm longis, ad apicem bracteolas binas latissime ovatas margine leviter ciliatas acutas circiter 2 mm latas ferentibus, floribus glabris, circiter 6 mm longis, calycis lobis triangulari-ovatis, acutis vel obtusis, 2 5 mm longis, margine leviter ciliato, corollae tubo glabro, 3 mm longo, lobis triangulari-ovatis, obtusis, 2 mm longis, recurvatis, filamentis glabris, 3 mm longis, antheris 2 mm longis, ovario glabro, globoso, stylis 3 5 mm longis

Sumatra, Tapianoeli, upper slopes and summit of Dolok Soeroengan, Habinsaran, *Bartlett 7991*, *8019* (type), May 18, 1927, one indicated as a six-foot shrub, the other as an epiphytic shrub

The alliance of this species is clearly with *Diplycosia heterophylla* Blume of Java and the Malay Peninsula, but it has much more numerous lateral nerves, thicker leaves, longer pedicels, and apparently larger flowers

Diplycosia Kingii, nom nov

Vaccinium microphyllum King & Gamble, in *Journ As Soc. Bengal*, 74 (2) 62 1905 (*Mater Fl Malay Penin*, 4 272 1905), non Blume

Diplycosia microphylla C B Clarke in Hook f, *Fl Brit Ind*, 3 458 1882, Ridl, *Fl Malay Penin*, 2 213 1923, non Becc

Sumatra, East Coast, Dĕlĕng Sinkoet, north of Bŏrastagi, Karo Plateau, *Bartlett 6597*, February, 1927 Malay Peninsula

Beccari 2991, from Mount Mattang, Sarawak, Borneo, of which I have a specimen, is the type of *Diplycosia microphylla* Becc, a species totally different from the Javan *Vaccinium microphyllum* Blume, which is a true Vaccinium

Rhododendron sumatranum, sp nov

Species *R retuso* ut videtur affinis differt fructibus perspicue pubescentibus, ramis teretibus, pallide brunneis, glabris, ramulis

ultimis 1 ad 1 5 mm crassis, angulatis vel sulcatis, plus minusve brunneo-lepidotis, foliis distanter verticillatis vel pseudoverticillatis, obovatis vel oblongo-obovatis, obtusis vel rotundatis, interdum obscure retusis, basi decurrenti-acutis, coriaceis, 2 5 ad 5 cm longis, 1 ad 2 5 cm latis, supra nitidis, pallidis, consperse cupreo-lepidotis, vetustioribus glabris, iunioribus subtus dense cupreo-lepidotis tarde consperse epidotis, vetustioribus punctatis haud lepidotis, margine revoluto, nervis lateralibus gracilibus, obscuris, utrinque 4 ad 6, costa supra impressa, subtus prominula, petiolo crasso, 5 ad 10 mm longo, floribus terminalibus, umbellatis, pedicellis fructiferis usque ad 3 cm longis, cupreo-lepidotis, fructibus ellipsoideis, circiter 2 cm longis, consperse cupreo-lepidotis albido-ciliatisque

Sumatra, Tapianoeli, summit of Dolok Soeroengan, Habinsaran, *Bartlett 7998*, May 18, 1927

A species in vegetative characters approximating *Rhododendron retusum* Benn , but with its fruits not only lepidote but also white-ciliate, with scattered hairs

Vaccinium Bartlettii, sp nov

Frutex erectus, circiter 2 5 m altus, multiramosus, ramis teretibus, glabris, ramulis multis, gracilibus, circiter 1 mm crassis, breviter pubescentibus, foliis numerosis, ellipticis, coriaceis, integris, circiter 1 cm longis et 5 mm latis, obtusis vel rotundatis, basi acutis, glabris, brevissime (ca 1 mm) petiolatis, supra pallidis vel pallide olivaceis, subtus pallide brunneis, obscure glandulosis, nervis primariis utrinque circiter 3, ascendentibus, obscuris, racemis axillaribus terminalibusque, 1 5 ad 2 cm longis, paucifloris, glabris, floribus circiter 5, pedicellis circiter 5 mm longis, calycibus 3 mm longis, tubo glabro, ovoideo, deorsum contracto, lobis 5, ovatis, acutis vel obtusis, 1 mm longis, utrinque breviter pubescentibus, disco pulviniformi, pubescenti, 2 mm diametro, ovario 5-loculari

Sumatra, Tapianoeli, summit of Dolok Soeroengan, Habinsaran, *Bartlett 8005*, May 18, 1927

Although the flowers are unknown, it seems safe to describe this as new because of its small, somewhat crowded, entire leaves and its racemose flowers In vegetative characters it suggests *Vaccinium Scortechinii* King & Gamble of the Malay Peninsula, but that species has solitary axillary flowers

Vaccinium urophyllum, nov sp

Frutex subscandens, ramis teretibus, glabris, ramulis ultimis circiter 1 mm crassis, leviter pubescentibus, foliis late lanceolatis vel oblongo-lanceolatis, perspicue longe tenuiter acute caudato-acuminatis, basi late acutis vel rotundatis, integris, opacis, olivaceis, 9 ad 11 cm longis, 2 ad 3 cm latis, glabris, subcoriaceis, nervis primariis utrinque circiter 7, tenuibus, curvato-ascendentibus, anastomosantibus, indistinctis, petiolo crasso, circiter 2 mm longo, pubescenti, racemis axillaribus solitariis, leviter pilosis, circiter 4 cm longis, paucifloris, laxis, floribus circiter 5, 8 mm longis, pedicellis consperse pilosis, 2 ad 2 5 cm longis, bracteolis lineari-lanceolatis, acuminatis, 2 mm longis, consperse pilosis, calycis tubo circiter 2 mm longo, piloso, lobis 5, oblongo-ovatis vel ovato-lanceolatis, utrinque pubescentibus, acuminatis, 3 mm longis, corolla subcampanulata, intus glabra, extus parcissime pubescenti, tubo 4 5 ad 5 mm longo, lobis ovatis, obtusis vel obtuse acuminatis 2 mm longis, staminibus 10, filamentis pilosis, 4 mm longis, antheris lanceolatis, 5 mm longis, tubulis rectis, obtusis, 3 mm longis, dorso calcaribus binis linearibus curvatis 1 5 mm longis donatis, ovario 5-loculari, stylis glabris, 7 mm longis

Sumatra, West Coast, Mount Singgalan, Fort de Kock, *Yates 2427*, May 19, 1927, scandent in forests at 1900 m altitude, flowers white

A species characterized by its lax, few-flowered racemes, long pedicels, small bracteoles, very slenderly caudate-acuminate, pinnately nerved leaves In leaf shape it rather strongly resembles *Vaccinium acuminatissimum* Miq , but is not at all allied to that species

MYRSINACEAE

Embelia microphylla, sp nov § Micrembelia

Frutex scandens, ramulis ultimis vix 1 mm crassis, dense breviter subferrugineo-pubescentibus, foliis numerosis, coriaceis, minutis, ellipticis vel ovato-ellipticis, 3 ad 8 mm longis, 2 5 ad 7 mm latis, glabris, apice rotundatis, basi late acutis vel subrotundatis, deorsum integris, prope apicem parce obscureque crenulatis, nervis primariis utrinque 3 ad 5, haud perspicuis, utrinque glandulis paucis magnis manifestis instructis, subtus glanduloso-punctatis, petiolo 1 ad 1 5 mm longo, inflorescentiis numerosis, lateralibus axillaribusque,

dense breviter pubescentibus, paucifloris, rhachibus usque ad 3 mm longis, bracteolis oblongis, usque ad 1 mm longis, floribus solitariis vel depauperato-racemosis, pedicellis usque ad 4 mm longis, ut videtur seriatim caducis, floribus 5-meris, calycibus 2 mm diametro, lobis triangulari-ovatis vel oblongo-ovatis, acutis, 0 8 mm longis, glandulis magnis paucis instructis, margine breviter ciliato, petalis ignotis, ovario glabro, glanduloso, stylis usque ad 1 3 mm longis, fructibus globosis, parce glandulosis, circiter 3 5 mm diametro

Sumatra, Tapianoeli, summit of Dolok Soeroengan, Habinsaran, *Bartlett 8022*, May 18, 1927

A characteristic species of the section Micrembelia in the group with *Embelia parviflora* Wall, but with distinctly smaller leaves, which bear a few teeth at their apices, very different, few-flowered inflorescences, which are short, racemose, and normally bearing but one flower at a time, these falling serially, and its glabrous ovaries Many of the immature fruits are curiously black-echinate, the radiate spinelike growths being as much as 1 5 mm long, exactly like similar growths on the young fruits of *Wallich 2294a*, *Myrsine bifaria* Wall = *M africana* Linn This character is due to infection with *Capnodium fructicolum* Pat (*Journ de bot*, 3 258 1889), a fungus originally described from infected fruits of a species of Myrsine from Yunnan The present species is, however, clearly an Embelia, not a Myrsine

Maesa oligotricha, sp nov § Eumaesa

Frutex scandens, ramulis et inflorescentiis et foliis subtus ad costam nervosque consperse ciliatis, ramis brunneis, ramulis ultimis plus minusve angulatis vel sulcatis, 1 5 ad 2 mm crassis, foliis chartaceis vel subcoriaceis, oblongis, 12 ad 20 cm longis, 3 5 ad 6 cm latis, longe (2 ad 3 5 cm) petiolatis, subtus lineis undulatis nervuliformibus perspicuis praeditis, caudato-acuminatis, basi late acutis vel subrotundatis, saepe leviter inaequilateralibus, supra olivaceis, glabris, vel ad costam consperse ciliatis, subtus ad costam nervosque consperse ciliatis, margine grosse distanter undulato-dentato, dentibus inter se 5 ad 15 mm distantibus, nervis primariis utrinque 8 ad 12, supra cum costa plus minusve impressis, subtus elevatis, perspicuis, inflorescentiis axillaribus, paniculatis, 4 ad 8 cm longis, ciliatis, ramis primariis paucis, rectis, 1 5 ad 4 cm longis, multifloris, floribus 5-meris breviter pedicellatis, in ramis

primariis racemose dispositis, bracteolis triangulari-ovatis, acuminatis, pubescentibus, circiter 1 mm longis, prophyllis ovatis, obtusis, 0 5 mm longis, vix cymbiformibus, pedicellis pubescentibus, circiter 0 5 mm longis, sepalis orbiculari-ovatis, rotundatis, 0 5 mm longis, haud lineatis, obscure glandulosis, margine brevissime obscure ciliato, corolla circiter 3 5 mm diametro, tubo brevissimo, lobis late ovatis, rotundatis, imbricatis, lineolatis, 1 5 mm longis, filamentis quam antheris duplo longioribus, fructibus globoso-ovoideis, glabris, circiter 2 5 mm longis

Sumatra, East Coast Delĕng Si Bajak, Karoland, *Bartlett 6514*, January 29, 1927, Goenoeng Sibajak, Karoland, *Yates 1507*, April 10, 1925

A species characterized by its elongated, oblong, rather coarsely sinuate-dentate, conspicuously lineolate, long-petioled, caudate-acuminate leaves and its indumentum of scattered pale, ciliate hairs Its alliance in accordance with Mez's arrangement of the species is apparently in the group with *Maesa sinensis* A DC, but it is not closely allied to any of the species in this series

OLEACEAE

Jasminum crassum, sp nov

Frutex scandens, glaber, ramis ramulisque teretibus, brunneis, foliis simplicibus, oppositis, crassissime coriaceis, ellipticis vel ovato-ellipticis, usque ad 15 cm longis et 10 cm latis, utrinque concoloribus puncticulatisque, nitidis, in statu sicco brunneis, basi late acutis vel subrotundatis, apice breviter abrupteque acuminatis, perspicue 3-nerviis vel subtriplinerviis, nervis longitudinalibus subtus valde elevatis, curvatis, apicem attingentibus, nervis secundariis transversalibus distantibus, haud perspicuis, utrinque circiter 6, margine revoluto, petiolo usque ad 1 cm longo, inflorescentiis lateralibus, axillaribus, anguste paniculatis, circiter 12 cm longis, floribus 7- vel 8-meris, circiter 3 cm longis, pedicellis crassis, 5 mm longis, calycibus cupulatis, 4 5 mm longis, lobis 7, crassis, triangulari-ovatis, acutis, circiter 1 2 mm longis, corollae tubo circiter 2 4 cm longo, lobis usque ad 8, patulis, oblongo-ellipticis, obtusis, circiter 15 mm longis et 6 7 mm latis

Sumatra, East Coast, Tandjoeng Pasir, Asahan, *Yates 1388*, March 15, 1925

A species apparently allied to *Jasminum smilacifolium* Griff of the Malay Peninsula, but with larger flowers and much broader petals, the leaves not at all caudate-acuminate

Jasminum multipetalum, sp nov (Tab XXXIV)

Frutex scandens, glaber, ramis ramulisque teretibus, gracilibus, ultimis vix 1 5 mm crassis, foliis simplicibus, oppositis, ellipticis vel oblongo-ellipticis, chartaceis, 10 ad 13 cm longis, 4 ad 5 5 cm latis, in statu sicco supra pallide griseis, nitidis, subtus pallidioribus, utrinque minute puncticulatis, acuminatis, basi acutis, 3-nervius, nervis longitudinalibus apicem subattingentibus, nervis horizontalibus utrinque circiter 9, cum longitudinalibus arcuato-anastomosantibus, subtus elevatis, petiolo articulato, circiter 6 mm longo inflorescentiis axillaribus, paucifloris, interdum 1-floris, pedunculo basi bracteis minutis squamiformibus instructo, pedicellis usque ad 3 cm longis, calycibus cupulatis, circiter 2 mm longis, dentibus 5 vel 6, ovatis, apiculatis, 0 5 mm longis, corollae tubo 2 2 mm longo, lobis circiter 13, patulis vel reflexis, rectis vel falcatis, lineari-lanceolatis, acuminatis, circiter 3 cm longis, deorsum usque ad 2 5 mm latis

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 371*, February-March, 1928

Linociera pubipaniculata, sp nov

Frutex vel arbor parva, partibus iunioribus inflorescentiisque exceptis glaber, ramis teretibus, pallidis, glabris, ultimis circiter 2 mm crassis, iunioribus compressis, leviter pubescentibus, foliis oblongis, chartaceis vel subcoriaceis, pallidis, nitidis, 13 ad 16 cm longis, 4 ad 6 cm latis, basi acutis, apice distincte acuminatis, margine revoluto, nervis primariis utrinque 10 ad 12, patulis, tenuibus, distinctis sed vix elevatis vel impressis, petiolo usque ad 1 cm longo, inflorescentiis axillaribus, paniculatis, multifloris, circiter 8 cm longis, pedunculatis, ramis inferioribus usque ad 3 cm longis, dense cinereo-pubescentibus, floribus sessilibus, plerumque in ramulis ultimis subcapitato-confertis, calycibus circiter 2 mm longis, pubescentibus, lobis 4, orbiculari-ovatis, rotundatis, circiter 1 mm latis, pubescentibus, corollae tubo 4 mm longo, lobis 4, oblongis, obtusis, 3 mm longis, bracteis ovatis, pubescentibus, 2 mm longis, ovario ovoideo, leviter pubescenti, stylis 1 mm longis

Sumatra, East Coast, Karoland, Pĕtjĕren, *Carel Hamel and Rahmat Si Toroes 777*, June 22, 1928

A species apparently allied to *Linociera malabarica* Wall, although its fruits are as yet unknown

APOCYNACEAE

Chilocarpus obtusifolius, sp nov (Tab XXXV)

Frutex scandens glaber, ramis ramulisque teretibus, pallide brunneis vel rubro-brunneis, ultimis circiter 2 mm crassis, foliis obovatis vel oblongo-obovatis, apice late rotundatis, basi cuneatis, coriaceis, 6 ad 11 cm longis, 3 ad 6 cm latis, supra olivaceis vel pallidis, nitidis, subtus pallidioribus, subglaucescentibus, consperse sed distincte punctato-glandulosis, nervis primariis utrinque numerosis (usque ad 40), parallelis, patulis, subtus distinctis, inflorescentiis terminalibus, usque ad 12 cm longis, multifloris, floribus parvis, in ramulis ultimis subumbellatim confertis, ramis primariis paucis, elongatis, partibus iunioribus leviter pubescentibus, bracteolis triangulari-ovatis, acutis vel acuminatis, vix 1 mm longis, pedicellis usque ad 3 mm longis, sepalis orbiculari-ovatis, rotundatis, 0 8 mm longis, margine obscure pubescenti, corollae tubo circiter 3 mm longo, leviter inflato, glabro, intus ad filamentorum insertionem obscure pubescenti, lobis inflexis, saltem 3 mm longis, antheris oblongis, 0 7 mm longis, basi obtusis, ovario ovoideo, glabro, stylis brevibus

Sumatra, East Coast, near Aek Kanopan and Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 6954, 7849* (type), March 17 and April 18, 1927 A vine with yellow flowers, in old jungle

A species well characterized by its broadly rounded, obovate to oblong-obovate, many-nerved leaves, which are pale, almost glaucous, and punctate, with small scattered glands on the lower surface, in general appearance approximating those of some species of Alstonia

Urceola longisepala, sp nov

Frutex scandens inflorescentiis ramulisque pubescentibus exceptis glaber, ramis teretibus, castaneo-purpureis, glabris, ramulis ultimis breviter pubescentibus, subsulcatis, circiter 1 5 mm crassis, foliis lanceolatis vel oblongo-lanceolatis, subcoriaceis, 5 ad 10 cm longis,

2 ad 3 cm latis, perspicue acuminatis, basi subrotundatis vel late acutis, supra brunneis, nitidis, subtus pallidioribus, nervis primariis utrinque circiter 7, perspicuis, arcuato-anastomosantibus, secundariis haud perspicuis, laxis, petiolo 1 ad 1 5 cm longo, glabro, inflorescentiis perspicue cinereo-pubescentibus, cymosis, terminalibus, circiter 4 cm longis, 4 ad 5 cm latis, multifloris, basi foliis binis parvis subtentis, ramis primariis 1 5 ad 2 5 cm longis, floribus parvis, confertis, bracteolis pubescentibus, oblongis vel oblongo-lanceolatis, usque ad 5 mm longis, calycis tubo brevi, pubescenti, lobis 5, oblongis, obtusis, pubescentibus, 2 ad 3 mm longis, 1 mm latis, corollam subaequantibus, ascendentibus vel patulis, corolla 3 mm longa, pubescenti, tubo ovoideo, 2 mm diametro, lobis oblongo-ovatis vel ovatis, pubescentibus, obtusis, erectis, vix 1 mm longis, filamentis brevibus, glabris, antheris lanceolatis, 1 5 mm longis, sagittatis, lobis obtusis, carpellis brevibus, glabris, discum glabrum subaequantibus

Sumatra, East Coast, near Aek Sordang, Loendoet Concession, Koealoe, in old jungle and secondary growth, *Bartlett 7590*, May 3, 1927, a large vine with latex

A species characterized by its lanceolate to oblong-lanceolate glabrous leaves, its small, cinereous-pubescent inflorescences, large bracteoles, elongated calyx segments, and short pubescent corollas, I have been unable to refer the species to any described form It seems to be allied to *Urceola malaccensis* Hook f of the Malay Peninsula

CONVOLVULACEAE

Erycibe dolichotricha, sp nov

Frutex scandens, ramulis et foliis subtus et inflorescentiis longe ferrugineo- vel castaneo-ciliatis vel hirsuto-ciliatis, pilis plerumque patulis, usque ad 3 mm longis, ramis elongatis, iunioribus partibus 1 ad 1 5 mm crassis, foliis oblongis vel oblongo-ovatis vel oblongo-ellipticis, chartaceis, olivaceis vel brunneo-olivaceis, nitidis, tenuiter acuminatis, 5 ad 7 cm longis, 2 ad 4 cm latis, breviter petiolatis, basi distincte cordatis, late rotundatis, utrinque consperse ciliato-pilosis, ad costam subtus dense ciliatis, nervis primariis utrinque circiter 6, gracilibus, petiolo 1 ad 3 mm longo, cymis axillaribus, plerumque solitariis, paucifloris, 0 8 ad 3 cm longis, subsessilibus vel distincte pedunculatis, dense ciliato-pilosis, pedunculo interdum

2 cm longo, floribus confertis, sessilibus vel inferioribus distincte pedicellatis, bracteis lineari-lanceolatis vel oblongo-lanceolatis, utrinque ciliatis, 3 ad 5 mm longis, sepalis petalisque in partibus expositis dense ciliato-hirsutis, petalorum partibus inflexis glabris, sepalis orbicularibus vel orbiculari-obovatis, 4 ad 5 mm latis, ovario glabro, fructibus iunioribus obovoideis, glabris, atris, saltem 7 mm longis

Sumatra, East Coast, Bandar Poeloe, Asahan, *Yates 2253*, Asahan River near Oedjoeng Batoe, above Bandar Poeloe, *Bartlett 6665* (type), February 21, 1927, between Soenggapa and Pargambiran, *Bartlett 6700*, February 22, 1927, near Aek Kanopan, Loendoet Concession, Koealoe, *Bartlett 7088*, March 26, 1927

The Yates specimen I first referred to *Erycibe Princei* Wall, and later placed all the specimens tentatively under *Erycibe tomentosa* Blume, from both of which it differs in its indumentum, which consists of long, usually spreading, golden brown to castaneous hairs, those on the exposed parts of the corolla-lobes being particularly densely arranged and distinctly shining The distinctly cordate leaves of the present species is another distinguishing character

Erycibe sumatrensis, sp nov

Frutex scandens, inflorescentiis parcissime pubescentibus petalisque in partibus expositis exceptis glaber, ramis pallidis, teretibus, ramulis circiter 1 5 mm crassis, foliis oblongis vel oblongo-ellipticis, pallide-olivaceis vel olivaceis, nitidis, glaberrimis, 9 ad 12 cm longis, 3 ad 4 cm latis, subcoriaceis, basi acutis, apice subcaudato-acuminatis, margine revoluto, nervis primariis utrinque 4 ad 6, distantibus, gracilibus, haud perspicuis, obscure arcuato-anastomosantibus, reticulis obsoletis vel subobsoletis, petiolo circiter 1 cm longo, inflorescentiis axillaribus, solitariis, racemosis, circiter 3 cm longis, parcissime pubescentibus glabrescentibus, circiter 8-floris, pedicellis usque ad 1 cm longis, glabris vel subglabris, bracteis lanceolatis, acuminatis, 4 mm longis, bracteolis minutis, oblongo-ovatis, obtusis, circiter 1 mm longis, floribus saltem 1 cm longis, sepalis orbiculari-reniformibus, circiter 4 mm latis et 3 5 mm longis, margine distincte dense pallide breviter ciliato excepto glabris, corollae tubo glabro, 2 ad 2 5 mm longo, segmentis extus oblongo-lanceolatis 7 mm longis in partibus expositis dense breviter subcinereo-pubescentibus, ceteroquin glabris, partibus inflexis late obovatis, bifidis

lobis late rotundatis, ovario subellipsoideo 2 mm longo, sursum leviter adpresse pubescenti

Sumatra, East Coast, Boenoet, Asahan, *Yates 2393*, April 24, 1927

A species characterized by being glabrous throughout except in its very sparingly pubescent inflorescences, its ciliate-margined sepals, and the densely pubescent exposed parts of its petals, as well as by its rather lax, solitary, axillary racemose inflorescences

LABIATAE

Gomphostemma Bartlettii, sp nov § Eugomphostemma

Herba robusta perspicue cinereo-pubescens, circiter 1 2 m alta, caulibus circiter 8 mm diametro, rotundato-angulatis, sulcatis, densissime stellato-pubescentibus, ramis ultimis 4 mm crassis, densissime molliter tomentosis indumento stellato-plumoso, foliis chartaceis, elliptico-ovatis, 16 ad 22 cm longis, 9 ad 13 cm latis, acutis vel obscure acuminatis, basi late acutis, supra olivaceis, simpliciter hirsutis, dense ad costam nervosque, pilis e basibus bulbosis in parenchymate conspersis, subtus densissime cinereo-pubescentibus, pilis stellatis in costam nervosque etiam plumosis, nervis primariis utrinque circiter 8, perspicuis, elevatis, arcuato-anastomosantibus, reticulis distinctis, margine denticulato, petiolo 4 ad 7 5 cm longo, dense stellato-pubescenti, verticillastris subcymosis, plerumque secus caulem aphyllum dispositis, multifloris, pedunculis inclusis dense cinereo-pubescentibus, rhachibus usque ad 1 cm longis, pedicellis usque ad 4 mm longis, bracteis parvis, lineari-lanceolatis, acuminatis, dense stellato-pubescentibus, circiter 4 mm longis, calycibus circiter 1 5 cm longis, haud costatis, extus dense stellato-pubescentibus, tubo cylindrico, sursum leviter ampliato, 8 mm longo et 4 mm diametro, intus glabro, lobis lineari-lanceolatis, graciliter acuminatis, circiter 6 mm longis, intus plus minusve hirsutis, corolla ignota, nuculis oblongo-obovoideis, rotundatis, glabris, 4 5 mm longis

Sumatra, Tapianoeli, between Panapparan and Pagar Batoe, Habinsaran, *Bartlett 7955*, May 17, 1927

A species manifestly allied to *Gomphostemma Curtisii* Prain of the Malay Peninsula, characterized by the dense stellate indumentum on the stems, inflorescences, and lower surfaces of the leaves, many of the hairs on the midrib and nerves being distinctly stellate-plumose,

those on the upper surface being simple from bulbous bases, scattered on the parenchyma, but dense on the midrib and nerves It differs from *G Curtisii* Prain in its larger leaves, shorter petioles, apparently different indumentum, densely pubescent peduncles, much smaller bracts, and other characters

Gomphostemma parvum, sp nov

Planta parva, circiter 15 cm alta, caulibus haud ramosis circiter 2 cm diametro, sulcatis, dense pallide breviter stellato-pubescentibus, foliis ellipticis, chartaceis, 6 ad 15 cm longis, 2 5 ad 5 cm latis, supra olivaceis, iunioribus disperse breviter stellato-pubescentibus, pilis hirsutis simplicibus conspersis cum stellatis intermixtis, glabrescentibus, subtus pallidioribus, ad costam nervosque dense breviter pallide stellato-pubescentibus, superficie consperse stellato-pubescentibus, basi obtusis vel late acutis, apice rotundatis vel late acutis, margine deorsum integro, sursum irregulariter dentato vel undulato-dentato, nervis primariis utrinque circiter 4, subtus perspicuis, arcuato-anastomosantibus, elevatis, reticulis laxis, petiolo 2 ad 3 5 cm longo, breviter stellato-pubescenti, floribus axillaribus, solitariis vel depauperato-fasciculatis, usque ad 4 5 cm longis, subsessilibus, bracteis lineari-lanceolatis, acuminatis, stellato-pubescentibus, quam calycibus paulo brevioribus, calycibus iunioribus distincte, vetustioribus obscure costatis, extus consperse cinereo-stellato-pubescentibus, intus hirsutis, lobis anguste lanceolatis, longe acuminatis, circiter 7 mm longis, tubum aequantibus vel tubo paulo longioribus, corollae tubo extus consperse pubescenti, deorsum 1 mm diametro, supra medium ampliato, lobis latis, nuculis ovoideis, glabris, circiter 6 mm longis

Sumatra, East Coast, along Aek Panialalangan, Pargambiran, Asahan, altitude 270 to 360 m , *Bartlett 8176*, May 22, 1927

A species manifestly allied to *Gomphostemma velutinum* Benth of Assam, as illustrated and described by Prain in *Ann Bot Gard Calcutta*, 3 269, Pl 98A 1901, but with narrower bracts, often solitary flowers, larger leaves, and apparently different indumentum The upper surfaces of the young leaves are supplied with scattered short stellate hairs and long stiff simple ones, the stellate ones deciduous, the simple ones more or less persistent, the very old leaves glabrous or nearly so At no stage of development are the leaves densely velutinous

Paraphlomis brevidens, sp nov

Herba usque ad 1 5 m alta, caulibus circiter 1 cm diametro, rotundato-angulatis, sulcatis, breviter adpresse retrorso-hirsutis, foliis membranaceis, oblongo-ovatis, 15 ad 30 cm longis, 7 ad 11 cm latis, supra glabris, olivaceis, subtus paulo pallidioribus, ad costam et nervos et reticula breviter adpresse pallide pubescentibus, margine brevissime denticulato, nervis primariis utrinque circiter 9, curvato-ascendentibus, subtus perspicuis, anastomosantibus, petiolo tenui, 2 ad 12 cm longo, breviter adpresse pubescenti verticillastris dense multifloris, bracteis lanceolatis, acuminatis, leviter pubescentibus, 2 ad 3 mm longis, calycibus 8 ad 9 mm longis, disperse breviter pubescentibus glabrescentibus, obscure 5-angulatis, sursum paulo ampliatis et 3 mm diametro, dentibus 5, apiculato-acuminatis, circiter 1 mm longis, tubo intus glabro, corolla saltem 1 2 cm longa, tubo circiter 1 mm diametro, deorsum glabro, 1 mm diametro, sursum plus minusve adpresse hirsuto, lobis extus dense pallide hirsutis, nuculis glabris, irregulariter compressis vel angulatis, oblongo-ovoideis, 8 mm longis

Sumatra, East Coast, Karoland, Bĕrastagi, *Yates 1558* (type), April 24, 1925, Dĕlĕng Sinkoet, north of Bĕrastagi, Karo Plateau, *Bartlett 8568*, June 24, 1927

A species manifestly allied to *Paraphlomis rugosa* (Benth) Prain, differing conspicuously in its very short calyx teeth and in the densely pubescent exserted part of its corollas I first thought that this might be *Gomphostemma sumatrense* Ridl, *Journ Mal Branch Roy As Soc* 1 85 1923, type from Bĕrastagi, but Ridley's unsatisfactory description does not apply sufficiently well to warrant this identification Prain describes and illustrates as Phlomis both *Paraphlomis rugosa* (Blume) Prain and *Paraphlomis oblongifolia* (Blume) Prain, *Ann Bot Gard Calcutta*, 9 59 60, Pl 73, 74 1901, and earlier, *op cit*, 3 231–232 1890, extensively discusses both of these and a third one, *Phlomis javanica* (Blume) Prain The last is very inadequately described, but two specimens from the original collection of the species, both labeled in Blume's handwriting, are in the herbarium of the New York Botanical Garden I can detect no constant characters by which this species can be distinguished from *Paraphlomis oblongifolia* (Blume) Prain The synonymy is as follows

PARAPHLOMIS OBLONGIFOLIA (Blume) Prain in *Ann Bot Gard Calcutta*, 9 60 1901

Leonurus oblongifolius Blume, *Bijdr*, 828 1826
Gomphostemma macrophyllum Miq *Fl Ind Bat* 2 988 1856
Phlomis oblongifolia O Ktz *Rev Gen Pl* 520 1891, Prain, in *Ann Bot Gard Calcutta* 3 231 1891, 9 59, Pl 73 1901
Leonurus javanicus Blume *loc cit*
Gomphostemma petiolare Miq *op cit*, 987
Phlomis javanica Prain in *Ann Bot Gard Calcutta* 3 231 1901

Java, Celebes

RUBIACEAE

Acranthera longipes, sp nov

Frutex parvus, caulibus glabris, circiter 8 mm diametro, foliis longe (7 ad 9 cm) petiolatis, chartaceis, oblongis, supra in statu sicco atro-olivaceis, glaberrimis, circiter 25 cm longis et 9 cm latis, utrinque subaequaliter angustatis, basi acutis vel leviter decurrenti-acuminatis, apice breviter acute acuminatis, olivaceo-brunneis, subtus pallidioribus, ad costam nervosque parce consperse adpresse hirsutis, glabrescentibus, nervis lateralibus utrinque circiter 11, subtus perspicuis, curvatis, prope marginem anastomosantibus, reticulis laxis, fructibus axillaribus, paucis, breviter pedicellatis, linearibus, glabris vel parcissime adpresse hirsutis, 4 ad 4 5 cm longis, 3 mm diametro, sepalis persistentibus oblongo-lanceolatis, acuminatis, 8 mm longis, 2 5 mm latis, graciliter 7-nerviis, bracteolis 4, oblongis, 3 mm longis

Sumatra, East Coast, Marbau, Bilah, near Bilah Pertama (Parbasiran), *Rahmat Si Toroes 315*, February–March, 1928

A species characterized by its long-petioled, nearly glabrous, oblong leaves and its slender elongated fruits

Acranthera Yatesii, sp nov

Frutex parvus, caulibus circiter 5 mm diametro, ciliato-hirsutis, plus minusve sulcatis et rotundato-angulatis, foliis oblongo-ellipticis, chartaceis, acutis, deorsum angustatis, basi cuneatis, 18 ad 20 cm longis, 7 cm latis, supra olivaceis, glabris, subtus pallidioribus, consperse breviter hirsutis, ad costam nervosque dense adpresse hirsutis, nervis primariis utrinque circiter 10, subtus perspicuis, curvatis, reticulis laxis, obscuris, petiolo 2 ad 3 cm longo adpresse hirsuto, stipulis subglabris, ovatis, 1 ad 1 5 cm longis, inflorescen-

tis axillaribus, fasciculatis, subsessilibus vel breviter pedunculatis, adpresse hirsutis, fructibus cylindricis, rectis vel curvatis, 3 ad 3 5 cm longis, circiter 3 cm diametro, adpresse hirsutis, bracteolis oblongis, hirsutis, 3 5 mm longis, sepalis persistentibus extus consperse hirsutis, oblongo-ovatis, obtusis vel acutis, circiter 6 mm longis et 4 mm latis, 4-nervus

Sumatra, East Coast, Simeloengoen, Tinggi Radja, *Yates 2153*, August 15, 1926, in forests, altitude about 500 m

The striking characters of this species are apparently its numerous straight or curved appressed-hirsute fruits, and its oblong-elliptic leaves, which are narrowed below, glabrous on the upper surface, and appressed-hirsute on the lower surface, particularly on the midrib and the lateral nerves

Hedyotis Kurzii, nom nov

Hedyotis galioides Wall, List no 866 1829 *nomen nudum* non F Muell 1863

Hedyotis Wallichii Kurz, in *Journ As Soc Bengal* 45 (2) 136 1876 Hook f *Fl Brit Ind*, 3 53 1880, Craib *Fl Siam Enum*, 2 52 1932 non Walp 1843

Oldenlandia Wallichii Craib, in *Kew Bull* 388 1911

Oldenlandia rosea Ridl in *Journ. Straits Branch Roy As Soc*, 59 110 1911, *Fl Malay Penin* 2 54 1923, non *Hedyotis rosea* Raf

Sumatra, Tapianoeli, between Langga and Pardoeaan, Habinsaran, *Bartlett 7766*

A new name is necessary here since the specific ones of Wallich, Kurz, and Ridley are invalid in Hedyotis I have specimens of this species from Burma, *Kuntze 6203*, and Borneo There is also a specimen of *Lobb 375* in the herbarium of the New York Botanical Garden, bearing a printed label "Java," but the locality "Moulmein" is written on it, so doubtless the specimen is from Burma

Mycetia brachybotrys, sp nov

Frutex circiter 2 5 m altus, partibus iunioribus inflorescentiisque plus minusve pubescentibus exceptis glaber, ramis incrassatis, pallidis, laevibus, nitidis, ultimis circiter 5 mm diametro, foliis obovatis vel elliptico-obovatis, chartaceis, 15 ad 30 cm longis, 7 ad 16 cm latis, perspicue acuminatis, deorsum angustatis, basi obtusis vel acutis, olivaceis vel atro-olivaceis, nitidis, supra glabris, subtus ad costam nervosque breviter pubescentibus, nervis primariis utrinque

14 ad 17, curvato-anastomosantibus, subtus cum costa reticulisque primariis perspicuis, elevatis, petiolo 1 ad 4 cm longo, stipulis oblongis vel oblongo-lanceolatis, acuminatis, rigidis, usque ad 2 cm longis et 7 mm latis, cymis lateralibus, vix 2 cm longis, solitariis vel fasciculatis, plerumque in axillis defoliatis, plus minusve pubescentibus, floribus circiter 12 mm longis, flavidis, siccis atris, tenuiter pedicellatis, pedicellis circiter 6 mm longis, bracteis ovatis vel lanceolatis, acuminatis, usque ad 3 mm longis, calycibus urceolatis, circiter 2 mm diametro, conspersе hirsutis, lobis 5, basi latis, longe acuminatis, 2 mm longis, corollae tubo 11 mm longo, 2 mm diametro, sursum leviter ampliato, glabro, lobis 5, oblongis, obtusis, 3 mm longis, staminibus 5, antheris oblongis 2 mm longis

Sumatra, East Coast, Dĕlĕng Singkoet, north of Bĕrastagi, Karo Plateau, *Bartlett 8574*, June 24, 1927 in the U S National Herbarium (type), Dĕlĕng Si Naboen (ascent from Kampong Goeroe Kinajan), Karoland, *Bartlett 8609* in the U S National Herbarium, Bĕrastagi, Karoland, *Yates 1542*, April 14, 1925

A species strongly characterized by its large leaves and its very short lateral inflorescences, which do not exceed 2 cm in length

Mycetia sumatrana, sp nov

Frutex parvus, glaber, ramis pallidis, laevibus, ramulis ultimis circiter 2 mm crassis, foliis olivaceis, chartaceis, oblongo-ellipticis, 10 ad 15 cm longis, 3 5 ad 5 cm latis, utrinque subaequaliter angustatis, apice tenuiter subcaudato-acuminatis, basi decurrenti-acuminatis, nervis primariis utrinque circiter 17, gracilibus, subtus elevatis, prope marginem curvato-anastomosantibus, petiolo 1 5 ad 2 5 cm longo, stipulis ovatis, acuminatis, circiter 1 cm longis, usque ad 7 mm latis paniculis terminalibus, solitariis, pedunculatis, pedunculis 5 cm longis, partibus floriferis pedunculum aequantibus, ramis primariis paucis, inferioribus 2 5 cm longis, pedunculo circiter 1 cm longo supra basin bracteas 4 verticillatas ferentibus quorum sunt binas ovatas 7 cm longas et 4 mm latas, binas lanceolatas, acuminatas, circiter 1 cm longas et 1 5 mm latas, bracteis superioribus bracteolisque late orbiculari-ovatis vel reniformibus, 1 ad 2 mm latis, margine papilloso, floribus 5-meris, pedicellis 5 ad 6 mm longis, calycibus cupulatis, circiter 2 mm diametro, lobis vix 1 mm longis acutis, corollae tubo circiter 1 mm longo, lobis 5, ovatis, acutis, tubum subaequantibus

Sumatra, Tapianoeli, along the Toba trail north of the Asahan River between Toetoepan and Si Makkoek, *Bartlett 7485*, April 21–25, 1927

A species characterized by being entirely glabrous, by its papillose-margined upper bracts and bracteoles, its very short corolla tubes, terminal solitary inflorescences, and by its peduncles being supplied about 1 cm above the base with a whorl of 4 conspicuous bracts, two of them being ovate and two narrowly lanceolate

Mycetia Yatesii, sp nov

Frutex subprostratus foliis subtus ad costam nervosque et inflorescentiis et ramulis ultimis breviter consperse pubescentibus exceptis glaber, ramis brunneis, plerumque laevibus, ramulis ultimis circiter 1 5 mm crassis, foliis lanceolatis vel oblanceolatis, chartaceis, 12 ad 21 cm longis, 2 ad 5 cm latis, utrinque subaequaliter angustatis, apice tenuiter caudato-acuminatis, basi cuneatis vel decurrenti-acuminatis, supra glabris, olivaceis, subtus pallidioribus, ad costam nervosque consperse breviter brunneo-pubescentibus, vetustioribus glabrescentibus, nervis primariis utrinque 13 ad 18, subtus elevatis, perspicuis, prope marginem curvato-anastomosantibus, reticulis primariis distinctis, subparallelis, petiolo 1 ad 2 5 cm longo, stipulis lanceolatis, acuminatis, usque ad 1 cm longis, inflorescentiis solitariis, lateralibus, axillaribus et in axillis defoliatis, 2 5 ad 3 5 cm longis, brunneo-pubescentibus, paucifloris, depauperato-paniculatis vel subracemosis, pedicellis gracilibus, 4 ad 8 mm longis, bracteis bracteolisque lineari-lanceolatis, acuminatis, leviter pubescentibus, 2 5 ad 4 mm longis, integris, floribus 4-meris, circiter 10 mm longis, calycibus breviter brunneo-pubescentibus, tubo cupulato, circiter 2 mm diametro, lobis 5, anguste lanceolatis, acuminatis, 2 mm longis, corollae tubo cylindrico, saltem 7 5 mm longo, extus parce pubescenti, intus piloso, lobis 5, oblongis, 2 mm longis, fructibus siccis ovoideis, circiter 4 mm diametro in vivo pellucidis

Sumatra, East Coast, Bandar Poeloeh, Asahan, *Yates 1641*, along the Toba trail from Pargambiran to Adian Langge, Asahan, *Bartlett 7692* (type), May 12, 1927, "sprawling shrub, yellow flowers, colorless transparent berries"

A species characterized by its lanceolate to oblanceolate, slenderly caudate-acuminate prominently nerved, elongated leaves,

solitary, rather short, lateral inflorescences and lanceolate entire bracts and bracteoles Its general alliance is with *Mycetia laterifolia* (Blume) Korth In many respects it agrees with Ridley's unsatisfactory description of *Mycetia angustifolia*, type from Běrastagi, but Ridley describes this as a tree 30 feet high, with glabrous leaves 4 to 8 inches long and 0 5 to 1 inch wide *Mycetia lanceolata* (Miq) O Kuntze, type also from Sumatra, has subterminal 3-flowered inflorescences

Ophiorrhiza Ridleyi, nom nov

Ophiorrhiza bracteata Ridl in *Journ Fed Malay States Mus* 8 (4) 47 1917, non Korth

Sumatra, East Coast, Běrastagi, *Yates 1529,* Tapianoeli, between Panapparan and Pagar Batoe, Habinsaran, *Bartlett 7940,* West Coast, Mount Singgalan at 1900 m altitude, *Yates 2433*

Ridley curiously overlooked Korthals' previous use of the same specific name for a very different Javan species

Wendlandia ovata, sp nov

Frutex glaber, ramis ramulisque teretibus, rubro-purpureis, foliis subcoriaceis, sessilibus vel subsessilibus, late ovatis, 4 ad 9 cm longis, 3 ad 6 cm latis, nitidis, apice late acutis vel obscure breviter acuminatis, basi latissime rotundatis, saepe leviter cordatis, subtus paulo pallidioribus, nervis primariis utrinque circiter 10, gracilibus, curvato-patulis, stipulis circiter 2 mm longis, abrupte apiculatis, paniculis terminalibus, pedunculatis, glaberrimis, circiter 10 cm longis, ramis inferioribus usque ad 7 cm longis, interdum bracteas foliaceas usque ad 1 cm longas ferentibus, floribus in ramulis ultimis plus minusve confertis, brevissime pedicellatis, calycibus glabris, 2 mm longis, lobis triangulari-ovatis, acutis, 0 5 mm longis, corollae tubo cylindrico, 4 5 mm longo, lobis ellipticis, obtusis, recurvatis, 1 5 mm longis

Sumatra, West Coast, Fort de Kock, *Yates 2501*, April 22, 1927, on cliffs at Haran Kloof, flowers white

A very strongly marked species, not only in being entirely glabrous, but also in its sessile to subsessile, broadly ovate leaves, which are broadly rounded and often slightly cordate at the base, these vegetative characters differing radically from those of all other de-

scribed Malaysian species Mr J M Cowan[2] in his recent monographic treatment of the genus recognizes fifty-seven species

CAPRIFOLIACEAE

Lonicera jasminifolia, sp nov § Nintooa, Longiflorae

Frutex scandens, glaber, ramis ramulisque teretibus, gracilibus, ultimis circiter 1 mm crassis, foliis chartaceis vel subcoriaceis, glabris, oblongo-ellipticis, tenuiter acute acuminatis, basi acutis, pallide olivaceis, 6 ad 9 cm longis, 2 ad 3 cm latis, costa subtus elevata, nervis primariis utrinque 4 vel 5, distantibus, gracilibus, haud perspicuis, obscure arcuato-anastomosantibus, reticulis obsoletis, petiolo usque ad 1 cm longo, articulato, pedunculis axillaribus, 2-floris, glabris, 1 5 cm longis, floribus binis, sessilibus, circiter 5 5 cm longis, bracteis lanceolatis, acuminatis, 1 5 mm longis, bracteolis suborbiculari-ovatis, 1 mm longis, calycibus glabris, 3 mm longis, lobis 5, ovatis, subacutis, 1 mm longis, corollae tubo 3 ad 3 5 cm longo, glabro, stylis gracilibus, parce conspersceque albido-hirsutis

Sumatra, Tapianoeli, Sibolga to Taroetoeng, *Yates 2534*, April 29, 1927, altitude about 1000 m , a vine with white flowers

A species characterized by its rather obscurely nerved leaves, the reticulations obsolete, its styles with rather widely scattered, white, more or less spreading, sometimes reflexed hairs It apparently belongs in the alliance with the Burmese *Lonicera leiantha* Kurz

CUCURBITACEAE

Melothria gracilipes, sp nov § Eumelothria

Planta annua, scandens, scaberrima, monoica, caulibus tenuibus, glabris, sulcatis vel angulatis, circiter 1 mm diametro, foliis plerumque 3- rariter 5-lobatis, rigidis, utrinque scaberrimis, usque ad 8 cm longis, margine integro vel distanter irregulariter serrulato, hispidissimo, lobis basilaribus patulis, oblongo-lanceolatis, acutis vel acuminatis, usque ad 4 cm longis, intermedio lanceolato, acuminato, usque ad 7 cm longo et 2 cm lato, supra olivaceis, albido-punctatis, punctulis papilloso-apiculatis, subtus pallidioribus, pallide hispidulis,

[2] Cowan, J M , "*The Genus Wendlandia*" *Notes Bot Gard Edinb* , 16 233-316, Pls. 232-235. 1932

basi truncatis vel leviter cordatis, petiolo hispido, circiter 2 cm longo, cirrhis simplicibus, parce hispidulis glabrescentibus, saltem 10 cm longis, inflorescentiis ♂ axillaribus, solitariis, longe pedunculatis, pedunculis gracilibus, glabris, usque ad 5 cm longis, floribus (deficientibus) numerosis, racemosis, confertis, pedicellis persistentibus gracilibus, glabris, 2 ad 10 mm longis, fructibus globosis, circiter 1 cm diametro, laevibus, glabris, in statu sicco pallidis, solitariis, pedunculo circiter 2 cm longo, seminibus numerosis, obscure marginatis, pallidis, foveolatis, obtusis, 3 ad 3 5 mm longis, oblongo-obovatis, leviter compressis

Sumatra, East Coast, Boenoet, Asahan, *Yates 1249*, December 21, 1924, Silo Maradja, Asahan, *Bartlett 7228* (type), April, 1927

This was first identified as possibly representing *Melothria affinis* King, of the Malay Peninsula and Borneo, but the tendrils are simple, not bifid, the leaves somewhat smaller and very differently lobed, as well as hispid, not pilose, on the lower surface It differs from *Melothria marginata* (Blume) Cogn , which is recorded from Sumatra, in its strictly globose fruits, which are not at all cylindric or rostrate

Siraitia, genus nov

Herba dioica, scandens, ut videtur annua Flores masculi paniculati Calycis tubus brevis, intus squamis 5 horizontalibus instructus, extus perspicue radiatim elevato-nervosus, nervis radiatis cum submarginalibus anastomosantibus, lobis 5, triangulari-acuminatis, brevibus, cum lobulis 5 brevibus obtusis alternantibus Corolla patule 5-partita, segmentis lanceolatis, acuminatis Stamina 5, libera, faucibus calycis inserta, filamentis linearibus, deorsum ampliatis, per paria approximatis, antherae uniloculares, sigmoideo-complanatae Flores ♀ et fructus ignoti

Siraitia Silomaradjae, sp nov

Caulibus scandentibus, partibus superioribus subrotundato-4-angulatis, 4-sulcatis, 3 mm diametro, cinereo-pubescentibus, foliis chartaceis vel submembranaceis, ovatis, late cordatis, breviter acuminatis, integris, olivaceis, circiter 17 cm longis et 14 cm latis, basi pedatim 9-nerviis, lobis basilaribus late rotundatis, supra consperse pubescentibus, pilis brevibus, flaccidis, subalbidis, subtus minute atro-papillulatis, petiolo circiter 9 mm longo, pubescenti,

cirrhis cinereo-pubescentibus, bifidis, saltem 15 cm longis, inflorescentiis ♂ axillaribus, longe (circiter 15 cm) pedunculatis, laxis, breviter pubescentibus, usque ad 25 cm longis, floribus ♂ 5-meris, pedicellatis, apertis, usque ad 3 cm diametro, calycibus circiter 1 3 cm diametro, 5-angulatis vel 5-lobatis, lobis triangularibus, acutis vel breviter acuminatis, cum lobulis 5 brevibus obtusis vix 1 mm longis alternantibus, tubo extus perspicue radiatim elevato-nervoso, nervis 10, pubescentibus, cum intramarginalibus rectangulariter anastomosantibus, corolla 5-partita, lobis lanceolatis, acuminatis, 7- vel 9-nerviis, circiter 1 5 cm longis, deorsum 5 mm latis, patulis, intus minute pallide subpapillulatis, extus minute atro-papillulatis, staminibus 5, per paria approximatis, filamentis circiter 4 mm longis, parce subpapillosis, deorsum ampliatis, antheris sigmoideo-conduplicatis, circiter 3 mm longis et 1 8 mm latis, obtusis, 1-locellatis, squamis 5, horizontalibus, triangularibus, obtusis vel acutis, circiter 2 mm longis

Sumatra, East Coast, Silo Maradja, Asahan, *H H Bartlett 8702a*, June, 1927

This new genus, dedicated to Professor H H Bartlett, seems manifestly to be allied to Thladiantha Bunge, from which it differs in its sigmoid-conduplicate anthers, its conspicuously elevate-veined calyces, the radial veins anastomosing directly with the equally conspicuous intramarginal vein in its five small calycine teeth alternating with the five larger lobes, and in its short broad perianth tube bearing at the insertion of the stamens five distinct lobes or appendages that extend horizontally inward over the calyx tube, the filaments being borne at the junction of these appendages with the perianth tube The stamens are arranged in two pairs, the odd one being solitary The pistillate flowers and fruits are as yet unknown The *generic name Siraitia is derived from the* Sumatran name of the collector, who made his botanical headquarters at Silo Maradja, Asahan, and was there adopted as a clan brother of the local chief Ria Maradja Si Rait Holboeng, "Siraitia" is a latinization of Si Rait

CAMPANULACEAE

Pentaphragma Bartlettii, sp nov

Caulibus glabris, plus minusve elongatis, saltem 15 *cm* longis, circiter 8 mm diametro, foliis subcoriaceis, oblongo-ovatis, pallide

brunneis, acutis vel leviter acuminatis, basi late acutis vel leviter decurrenti-acuminatis, leviter inaequilateralibus, 20 ad 25 cm longis, 10 ad 12 cm latis, supra glabris, subtus plus minusve pallide breviter furfuraceo-pubescentibus vel stellato-furfuraceis, margine deorsum integro, sursum distincte dentato, nervis primariis utrinque 3 vel 4, distantibus, subtus valde perspicuis, curvato-ascendentibus, nervis secundariis perspicuis, laxe arcuato-anastomosantibus, petiolo 4 ad 5 cm longo, inflorescentiis axillaribus, ut videtur brevibus, scorpioideis, leviter furfuraceis, bracteis tenuibus, oblongis vel ovatis, obtusis, pallidis, leviter furfuraceis, 7 ad 9 mm longis, 3 ad 5 mm latis, fructibus cylindricis vel oblongo-obovoideis, leviter furfuraceis, circiter 1 cm longis et 5 mm diametro, sepalis persistentibus, inaequalibus, obtusis, maioribus oblongo-obovatis 5 mm longis et 3 mm latis, minoribus late oblanceolatis 4 5 mm longis et 1 8 mm latis

Sumatra, Tapianoeli, along the Toba trail north of the Asahan River between Toetoepan and Si Makkoek, *Bartlett 7495*, April 21–25, 1927

I was at first inclined to refer this to *Pentaphragma sumatrana* Ridl , but it differs from Ridley's description in its glabrous stems, larger, acute or acuminate, fewer-nerved leaves, much longer petioles, differently shaped bracts, and glabrous or nearly glabrous sepals

Pentaphragma integrifolium, sp nov

Herba humilis, caulibus haud ramosis, 2 ad 6 cm longis, circiter 3 5 mm crassis, partibus iunioribus furfuraceis, foliis integris, ovatis, oblongo-ovatis, ellipticis vel obovatis, plus minusve inaequilateralibus, integris, apice rotundatis, basi rotundatis vel acutis, plerumque 5-nerviis, 10 ad 15 cm longis, 6 ad 10 cm latis, supra olivaceis, glabris, subtus pallidioribus, consperse pallide furfuraceis, nervis primariis supra basin utrinque 2 vel 3, ascendentibus, subtus perspicuis, secundariis paucis, curvatis, vix arcuato-anastomosantibus, petiolo plus minusve furfuraceo, 1 ad 2 cm longo, inflorescentiis axillaribus, solitariis vel binis, scorpioideis, 3 ad 4 cm longis, pedunculo circiter 1 cm longo, dense furfuraceo, floribus confertis, biseriatis, sessilibus, parvis, bracteis membranaceis, oblongo-ellipticis vel elliptico-oblanceolatis, rotundatis, leviter furfuraceis, circiter 6 mm longis et 3 mm latis, plerumque deorsum angustatis, basi acutis, calycis tubo circiter 5 mm longo, deorsum leviter an-

gustato, leviter furfuraceo, lobis membranaceis, inaequalibus, consperse debiliter pilosis, maioribus oblongo-ellipticis, obtusis, 3 mm longis, 2 mm latis, minoribus dimidio angustioribus, petalis 4, glabris, oblongis, rotundatis, 3 mm longis et 2 mm latis

Sumatra, East Coast, near Aek Sordang, Loendoet Concession, Koealoe, *Bartlett 7572*, April 30, 1927, near Si Sahang waterfall, Pargambiran, Asahan, *Bartlett 6787*, February, 1927, Bandar Poeloe, Asahan, *Yates 2597* (type), near Oedjoeng Batoe, above Bandar Poeloe, *Bartlett 6639*, February, 1927, Marbau, Bilah, near Bilah Pertama, Parbasiran, *Rahmat Si Toroes 151*, March, 1928

A species apparently belonging in the group with *Pentaphragma begoniaefolium* Wall of the Malay Peninsula, but with very differently shaped, only slightly inequilateral, entire, rounded leaves and 4-merous flowers

Var **longipetiolata** var nov

A typo differt petiolo elongato, 2 5 ad 5 cm longo

Sumatra, East Coast, Silo Maradja, Asahan, near Taloen Djoring, *Rahmat Si Toroes 61*, December, 1927 The specimen differs further in its more elongated stems, about 15 cm long, and may ultimately prove to be specifically distinct The inflorescences are very young

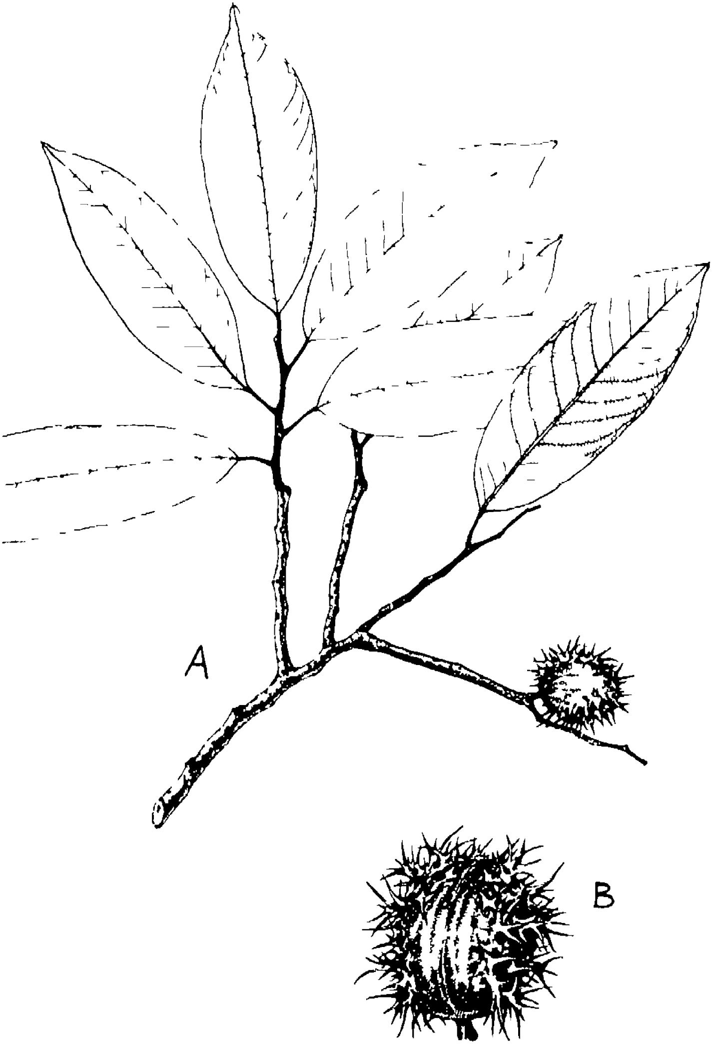
New York Botanical Garden
Bronx Park New York

PLATES XVI–XXXV

PLATE XVI

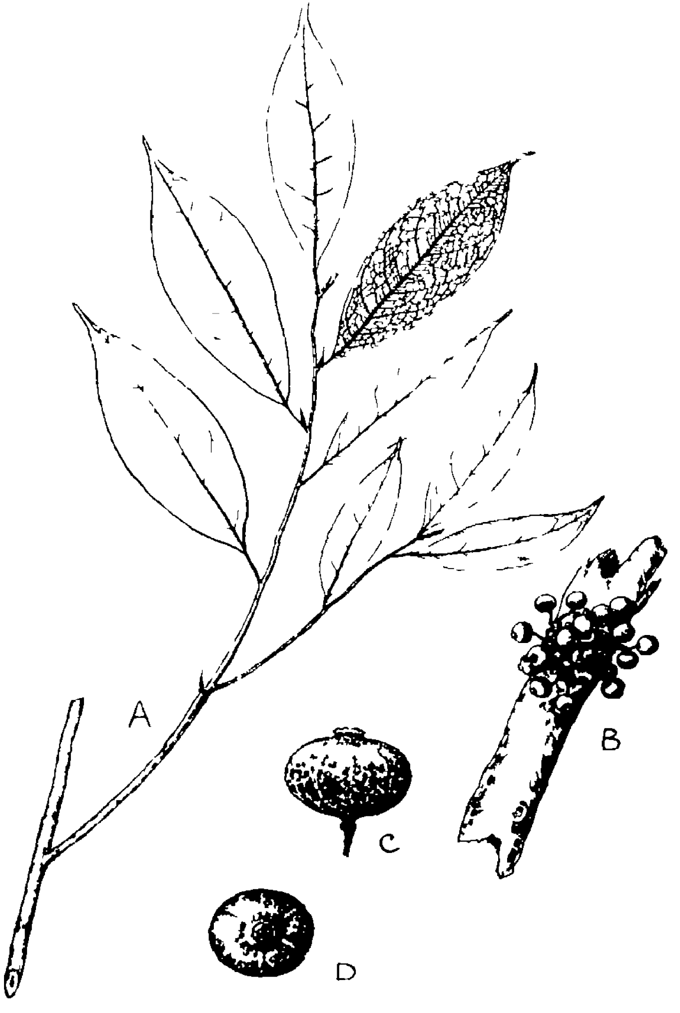
Homalomena longipes Merrill sp nov *A* habit sketch × ½ *B* a spathe × 2½

PLATE XXVII



anopsis conspersispina Merrill sp. nov. A, a branch × ½; B, a fruit × 1

PLATE XVIII



Ficus Yatesii Merrill sp. nov. *A*, a branch × ½; *B*, an infructescence × ½; *C–D*, a receptacle × 1½.

PLATE XIX

sterrophyllum Merrill sp. nov. *A*, a flowering branch, × ½; *B*, a flower, ×

PLATE XX

Bauhinia gracilipes Merrill sp. nov. A leafy branch and an inflorescence × ½

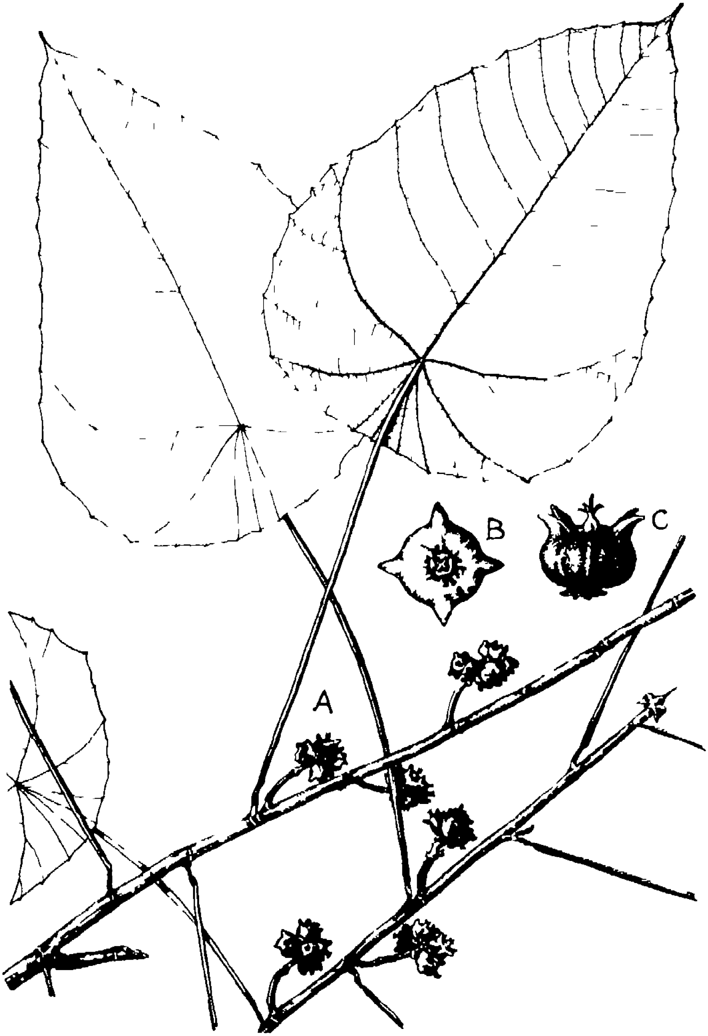
PLATE XXI

hma Ral mata Merrill sp nov A leafy branch with flowers ½

PLATE XXII

Sarcotheca ferruginea Merrill sp. nov. *A*, a leafy branch × ½; *B*, a fruit × 2.

PLATE XXIII



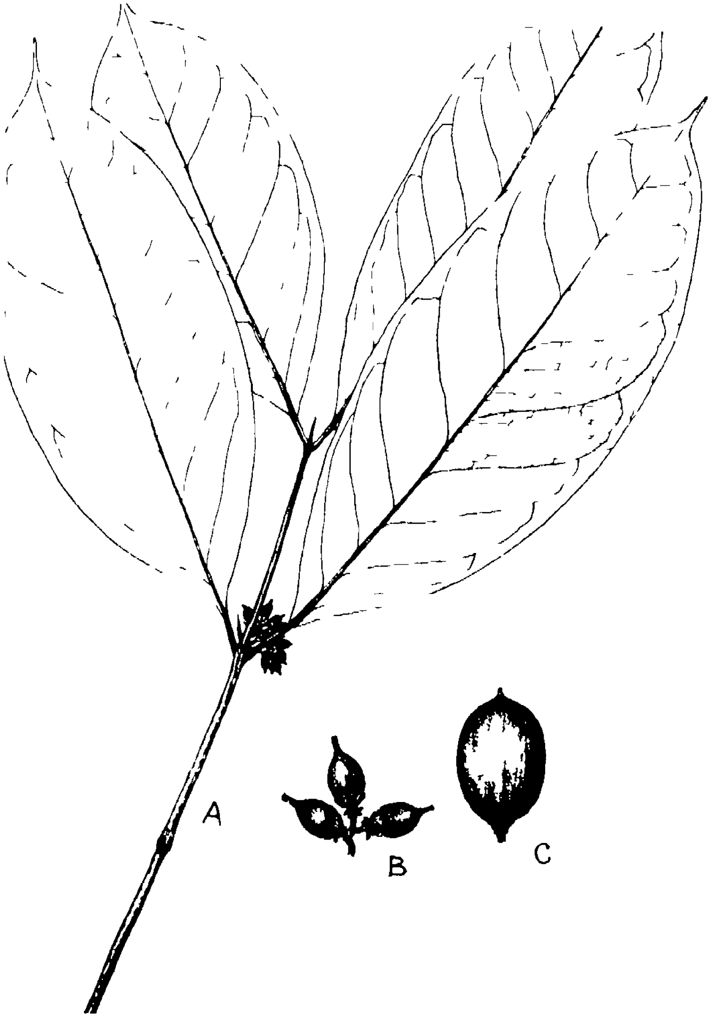
Macaranga Bartlettii Merrill sp. nov. *A*, a leafy branch × ½; *B–C*, fruits × 2

PLATE XXIV

Ilex apiculata Merrill sp. nov. A, a leafy branch × 1; *B*, a fruit × 2; *C*, a leaf × 3

PLATE XXV

Ilex grandifolia Merrill sp. nov. *A*, a leafy branch with inflorescences × ½; *B*, part of an infructescence, very slightly enlarged.



Microtropis sumatrana Merrill sp. nov. *A*, a leafy branch × ½. *B*, part of an infructescence × 1. *C*, a fruit × 2.

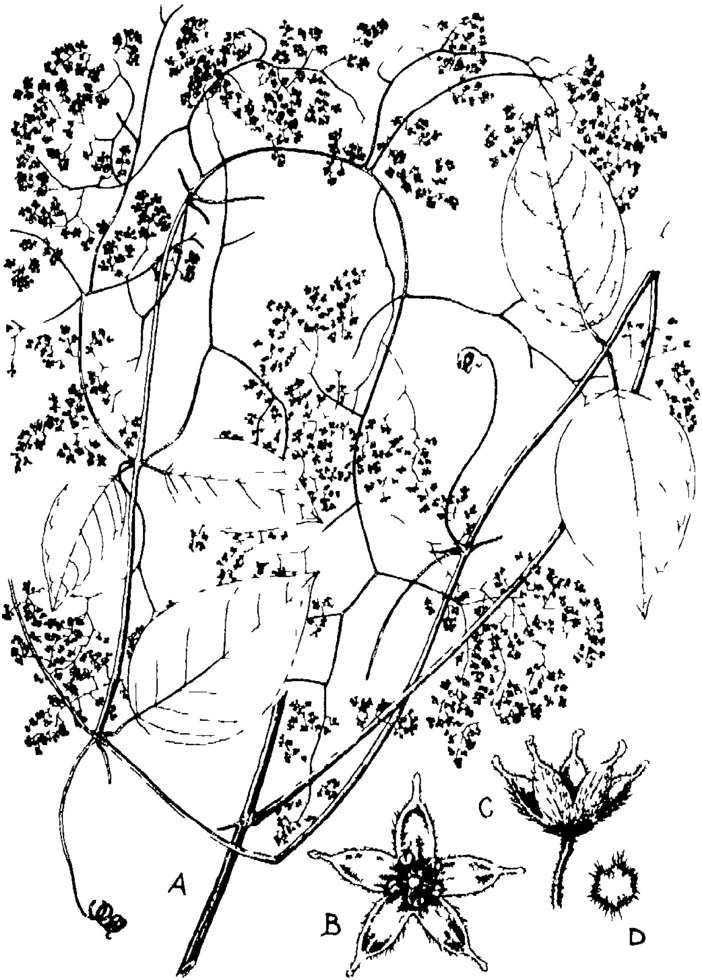
PLATE XXVII

Gomphandra subrostrata Merrill sp. nov. *A*, a leafy branch × ½; *B*, a fruit × 1.

PLATE XXVIII

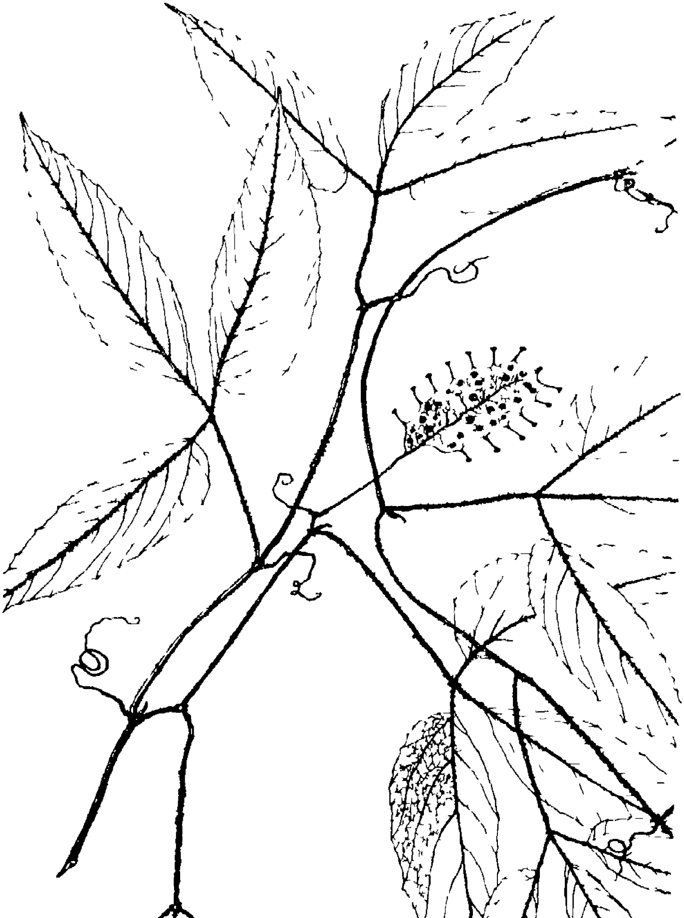
Gomphandra Yatesii Merrill sp. nov. *A*, a leafy branch × ½; *B*, a stamen × 6; *C*, a mature bud × 5; *D*, an ovary × 1; *E*, a petal × 6.

PLATE XXIX



Iodes floribunda Merrill sp. nov. *A*, a leafy branch with staminate inflorescences × ½; *B*, a staminate flower viewed from above × 7; *C*, side view of a flower × 6; *D*, a calyx × 5.

PLATE XXX



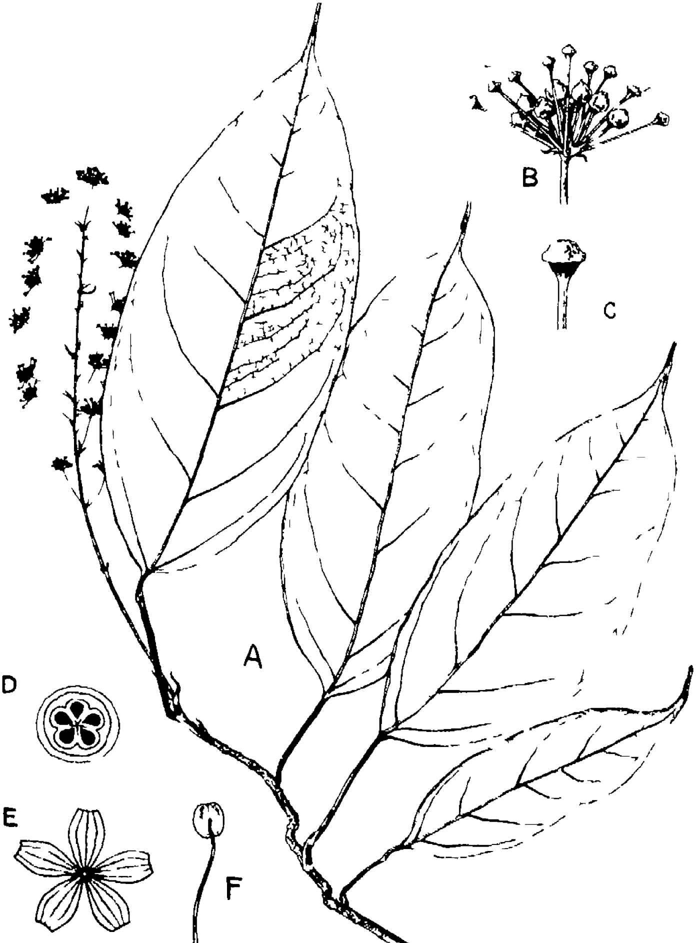
Pterisanthes heterotricha Merrill, sp. nov. A leafy branch with an inflorescence × ½

PLATE XXXI

Sterculia patentinervia Merrill sp. nov. *A*, a leafy branch; *B*, a staminate flower × 3.

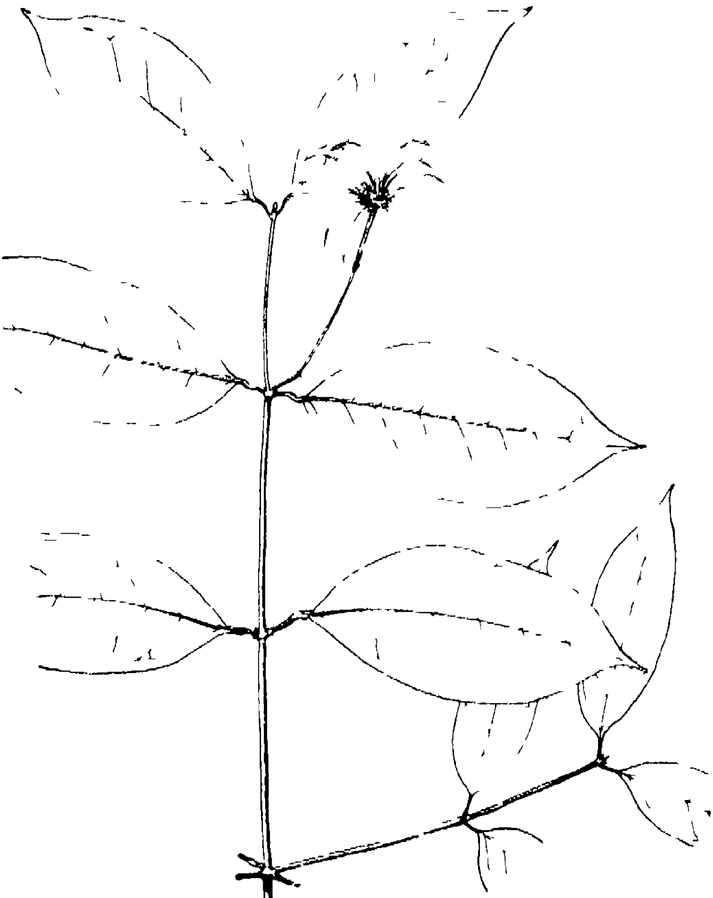
urophylla Merrill sp. nov. *A*, a leafy branch × ½; *B*, a staminate flower × 1½.

PLATE XXXIII



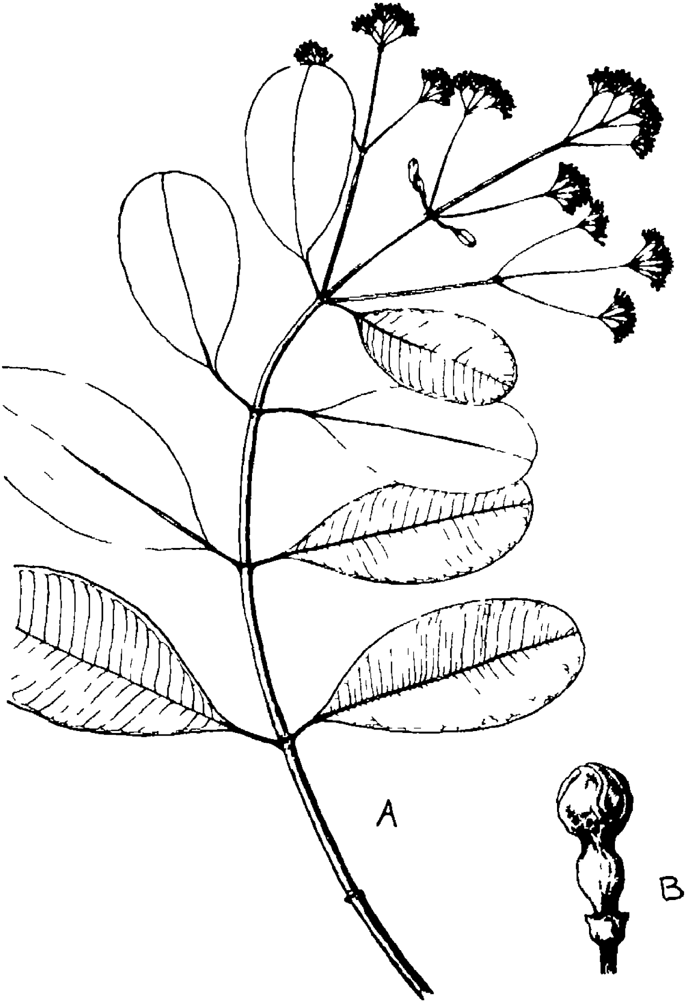
Schefflera Bartlettii Merrill sp. nov. *A*, a leafy branch with a single inflorescence × 1; *B*, an umbel × 4; *C*, a young fruit × 4; *D*, cross section of an ovary × 8; *E*, the five petals cohering by their tips × 6; *F*, a stamen × 6.

PLATE XXXIV



Jasminum multipetalum Merrill sp. nov. A leafy branch with a single flower × ½

PLATE XXXI



Chilocarpus obtusifolius Merrill sp nov *A* a leafy branch × ½
B a nearly mature bud × 5

UNUSUAL AGARICS FROM MICHIGAN *

ALEXANDER H SMITH [1]

THE season of 1932 was exceptionally fine for fleshy fungi in general, and many interesting agarics were collected by the writer Most of them, which were from the vicinity of Ann Arbor, were gathered during the late summer and fall During the early part of June the writer accompanied Professor E B Mains on a short trip to the region about Harbor Springs. Several very interesting late spring and early summer species were found at that time In addition, a few species collected previous to 1932, but still unreported, have been included, either because of their reappearance during the past season or because of their exceptional interest

Thirty species are treated, twenty-one of which have apparently not been previously reported as occurring within the state. The remainder are interesting partly because they furnish excellent illustrations of the sporadic appearance of species in this family and partly because of the additional information obtained concerning their identity and variations

The collection numbers, determinations, and photographs are those of the writer unless otherwise stated All the collections have been deposited in the Herbarium of the University of Michigan

ARMILLARIA CALIGATA Viv (Pl XXXVI) — This apparently rather rare species was found in three localities near Ann Arbor during the season of 1932 As Kauffman (4) has pointed out, besides the odorless form which he collected there are apparently two others, one characterised by a "fruity" odor and the other by a pungent, disagreeable odor All three forms were collected during the season of 1932. The collections from one locality were characterised by the presence of a marked "fruity" odor, or, as Bresadola (1) has described it, "odore grato ut in *Inocybe piro-*

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 427

[1] The writer wishes to express his appreciation to Professor E. B. Mains for interest and advice in the preparation of this paper

dora" In addition to the fruity odor the important features are the dark chestnut-brown fibrillose scales on the pileus and on the stipe below the annulus, the parallel hyphae of the gill trama, and the spores, which measure 7 8 × 5 5 5 μ Two collections of the form with the disagreeable odor were found This is apparently *A nardosmia* Ell The hyphae of the gill trama were found to be parallel, and the spores measured 6 5–8 × 5–5 5 μ The scales on the pileus and stipe were also characteristic The fruit-bodies lacking an odor were found in the locality where Professor Kauffman collected his specimens, and were identical with his in every respect When fully mature the scales on the pilei of all three forms tend to separate, and as a result the surface is covered by streaks of brown fibrils

Since the three forms are alike in all characters except the odor, and since each has been found to be constant for that character in its own locality, the following arrangement seems desirable

Armillaria caligata Viv — Typified by the fruity odor Nos 32 329, Sept 2, 1932, 32–499, Sept 27, 1932, 32–567, Aug 12, 1932, 92331, Sept 23, 1931, 9932, Sept 9, 1932 All these collections were from the same locality near Ann Arbor, Mich

Armillaria caligata Viv f **inodora**, f nov — A typo differt odore nullo Specimen typicum in Herb Mich conservatum, prope Chelsea, Mich A H Smith No 32–543, Oct 8, 1932

Armillaria caligata Viv f **nardosmia** (Ellis), comb nov (Pl XXXVII) (*Agaricus nardosmius* Ellis, *Bull Torr Bot Club,* 8 75 1876, *Armillaria nardosmia* (Ellis), P Saccardo, *Sylloge Fungorum,* 5 74) Ann Arbor Nos 32–498, Sept 27, 1932, 32–568, Oct 10, 1932 Both collections were from the same locality near Ann Arbor

Clitocybe tortilis Fr — On wet muck in a low woods, Ann Arbor No 32–524, Oct 6, 1932

Clitocybe trullisata Ellis — Found in the sand at Muskegon State Park, Oct 5, 1932, by George W Fischer This species is interesting because of its habitat and its relationship to the Laccaria group

Collybia delicatella Pk — Pileus 0 5–3 mm broad, broadly campanulate to plane when expanded, surface appearing as if pruinose or frosted when viewed under a lens, faintly striate, flesh opaque,

pure white, margin remaining incurved for a long time lamellae adnate, narrow, moderately close to distant, pure white, rather thick for such a small plant, stipe 8-10 (15) mm long, filiform, pure white, faintly pruinose or pubescent under a lens, inserted on needles by a base which is more pruinose than the stipe, spores 9-10 × 2 5 3 μ, no cystidia seen, basidia two-spored On spruce needles, Saginaw Forest, Ann Arbor No 32 275, Aug 12, 1932

The type at the New York State Museum, Albany, was found to have spores 9–11 × 3-4 μ, two-spored basidia, and no differentiated sterile cells or cystidia The pure white pileus stipe and gills, pruinose stipe, broadly convex or plane pileus, and the broad, incurved margin aid in distinguishing this species

Collybia misera Fr (*sensu* Bresadolae) (Pl XXXVIII, Fig 1) — Pileus 4–10 mm broad, convex or partly expanded, with a broad umbo, evenly fuscous at first, remaining fuscous on the disk, margin fading to drab, often with brownish tints, lubricous, densely pruinose at first, lamellae distant to subdistant, broad, adnate or arcuate-adnate, drab with a whitish sheen, edge minutely eroded, concolor, stipe 1–3 cm × 1 1 5 mm, concolor with pileus and furfuraceous at apex, pruinose over all at first, tubular, cartilaginous, taste faintly farinaceous, odor none, spores 8 5–9 5 × 4–5 μ, broadly ellipsoid, basidia four-spored, sterile cells clavate with short projections over the apex, not numerous Gregarious on hummocks in a larch swamp, Ann Arbor Nos 32–637, 32–638, 32–639, 32–640, Oct 20, 1932

The base of the stipe is often stained brownish Bresadola describes the spores as 9–11 × 5–6 μ, and the basidia as two-spored Such a difference in spore size is to be expected between two- and four-spored forms and in itself does not constitute a serious objection Bresadola (1) does not figure any sterile cells or cystidia The Michigan collections possessed the roughened clavate type on the gill edge, but, because of the close resemblance in all other respects, the writer believes that these collections belong here

Collybia tenuipes (Schw) Sacc — This species has apparently been collected in Michigan twice before (Pieters, 1894, Baxter, 1920) During the early part of June, 1932, Professor Mains and the writer encountered it rather frequently in the vicinity

of Harbor Springs, Michigan It seemed to prefer decaying beech logs Nos 32-45, 32-45a, June 4, 1932, 32-45b, June 5, 1932, 32-66, June 7, 1932

CORTINARIUS ELEGANTIOIDES Kauff — A single collection of large well-developed fruiting bodies was made The pilei measured 8-11 cm broad The colors and markings were typical, however, and the spores are similar to those of the type Collected in a low woods under oak and maple Pinckney No 32-420, Sept 15, 1932

CORTINARIUS LUTEUS Pk — Pileus 2-5 cm broad, convex when young, broadly and obtusely umbonate or expanded-plane, breaking up into very minute dotlike scales in age, "sepia"[1] to "brownish olive" on disk, fading to "old gold" on the margin, flesh thick on disk, thin on the margin, "old gold" also, lamellae moderately close to subdistant, broadly adnate or slightly decurrent, equal but becoming slightly ventricose in age, edge slightly eroded, "straw yellow" to "mustard yellow" when young, becoming "ochraceous-tawny" in age and rather spotted, stipe 4-8 cm long, 5-10 mm thick, fibrous, solid, slightly annulate from the "citron yellow" cortina, "naphthalene yellow" over all, but soon becoming sordid "ochraceous-tawny," base at times remaining "citron yellow", cortina pale yellowish but soon fading to white, spores 6-6 5 × 6 μ, slightly roughened, broadly ellipsoid to globose In mixed woods at Harbor Springs No 32-67, June 6, 1932 At Wilderness State Park it was abundant on June 7, 1932 (Nos 32-87, 32 88) Such an early appearance is exceptional in the genus Cortinarius

CORTINARIUS OLIVACEO-STRAMINEUS Kauff — Gregarious on humus in a dense thicket of witch-hazel Ann Arbor No 32-322, Sept 1, 1932

CORTINARIUS PINETORUM Kauff — When young the fruit bodies are white, but they change to buff or light brown as they mature The older fruit bodies are often quite sordid The stipe is white, silky fibrillose, and clavate to oval-bulbous The spores measured 8-10 × 4 5-5 μ, were slightly roughened, and were pale cinnamon under the microscope Although it is near *C caespitosus Pk*, the spores indicate that it is more properly placed in this speci

[1] All names of colors within quotation marks are taken from R. Ridgway, *Color Standards and Color Nomenclature*, 1912

The specimens were found growing subcespitosely on the humus in a deciduous woods near Pinckney No 32-433, Sept 15, 1932

CORTINARIUS RUBROCINEREUS Pk — Pileus 3-7 cm broad, reddish ashy to pinkish buff, faintly fibrillose, lamellae broad, subdistant, uncinate, violaceous, soon cinnamon-brown, stipe 4 9 cm × 1 2 5 cm, bulb oval, 2 3 cm thick, violaceous beneath the white remains of the universal veil, flesh purplish at first, soon whitish, spores 7 5–10 × 5–5 5 μ On a sandy ridge under aspen and oak Pinckney No 32–419, Sept 15, 1932

CORTINARIUS VELICOPIA Kauff — Gregarious on humus in low open woods Pinckney No 32-434, Sept 15, 1932

FLAMMULA AMARA Bull (*sensu* Ricken) – Cespitose beneath the roots of a larch stump Pinckney Oct 10, 1931

FLAMMULA CARBONARIA Fr (Pl XXXIX) — Pileus 1–2 5 cm broad, convex, becoming expanded or the margin remaining decurved, umbo none or very slight, "russet" or "tawny" at first, fading to "ochraceous-buff," margin often paler and fibrillose from the remains of the veil, surface slightly viscid, flesh thick on the disk, yellowish, taste slightly bitter, lamellae pallid or pale yellowish, becoming cinnamon from the spores, close, broad, adnate, in age becoming sinuate, margin slightly eroded, stipe 1–3 cm × 2–5 mm, broadest above, whitish to "mustard yellow" at the apex, brownish in age, darker below, fleshy, hollow, fibrillose from the veil, spores 6–7 5 × 4 μ, narrowly oval, basidia 18–24 × 5–6 μ, four-spored, cystidia numerous, 40–60 × 10–15 μ, hyaline, fusoid-ventricose, *no metaloid cysts seen* On burned-over ground around larch and spruce stumps, Whitmore Lake Nos 32–10, May 5, 1932, 51332, May 13, 1932, 32–221, May 15, 1932, 32 221a, May 15, 1932

The peculiar cysts emphasized by Kauffman (6) for *F highlandensis* Pk were lacking in these collections The fungus was not abundant in the burned area at any one time, but was collected throughout the season

FLAMMULA LIQUIRITIAE Fr — Pileus 4–9 5 cm broad, convex to plane, margin decurved, dry, pellicle not separable, not hygrophanous, neither shining nor fibrillose, minute patchlike scales visible under a lens, "ochraceous-orange" to "zinc orange," becoming "ferruginous," "cinnamon-rufous," or "hazel," usually evenly colored, lamellae depressed-adnate when young, adnexed

in age, broad (11 mm), close, broadest behind, tapering evenly to the margin, "yellow ocher" when young, becoming ferruginous in age or when bruised, not separable, edge even, stipe 2–4 cm × 4–7 mm, "yellow ocher" when young, with a paler apex, becoming ferruginous in age, stuffed, appearing attached to substratum by a broad yellowish mat of mycelium giving the lower portion an inflated appearance, the base of the stipe usually projecting through this into the wood, excentric or central depending on the point of attachment to the substratum, at first covered with yellowish fibrils or pruinose over all, finally glabrous, spores pale ochraceous under the microscope, 7–8 × 5–6 μ, between "ochraceous-orange" and 'yellow ocher" in mass, cystidia none, taste bitter, odor none On old elm and oak logs, Ann Arbor Oct 8, 1931

This species seems to prefer a coniferous substratum The Michigan collection was compared with specimens collected on coniferous wood, but no important differences could be found

HYGROPHORUS PALUDOSUS Pk — Pileus 5 10 cm broad, convex or obtusely conical, broadly depressed in age, covered by the remains of the universal veil in the form of a layer of gluten 2–3 mm thick or often in masses 5 mm thick, gluten hyaline at first but giving an ochraceous sheen to the pileus in even the unexpanded sporophores, almost cinnamon in age, showing a brown "netted" pattern, whitish, pinkish vinaceous, or faintly purplish beneath the gluten, flesh thick, white, soon cut up by grubs, gills adnate then decurrent, moderately broad, tapering toward both the margin and the stipe, close to subdistant, becoming sordid-greenish spotted in age, stipe 6–10 cm × 1–1 5 cm equal, base narrowed to a short rootlike prolongation, glutinous over part of its length from the universal veil, white scabrous-dotted above at first, in age the dots becoming sordid yellowish, annulate from the veil, sordid concentric circles often caused by the drying gluten, white and solid within, odor and taste none, spores 8–10 × 5 7 μ, broadly ellipsoid, basidia four-spored, gill trama of divergent hyphae Pinckney, No 32–436, Sept 15, 1932, Ann Arbor, No 32–574, Oct 14, 1932

When well developed this is one of the most striking species in the subgenus Limacium The greenish stains on the lamellae are very conspicuous, as are the yellowish dots at the apex of the

stipe This species was collected first by Professor Longyear at Greenville, Michigan, and sent to Dr Peck who in 1902 described it as a new species Previous to this year (1932) it has apparently been known only from the type locality

INOCYBE PALUDINELLA Pk (Pl XL, Fig 2) — This small species was described by Peck from New York and apparently has not been previously reported outside that state It resembles *I geophylla* in stature and color, but differs in having angular-tuberculate spores Whitmore Lake, Aug 8, 1920 This determination was checked by Professor Kauffman

LACTARIUS BOUGHTONI Pk — Pileus 2–5 (10) cm broad, at first obtuse, flattened or convex, "walnut brown," firm and brittle, at length subexpanded, depressed in the center, "cacao brown" to "Japan rose" when young, covered by a hoary film, pruinose, surface finally becoming minutely subtomentose-pruinose, flesh whitish, thick, unchanging, lamellae subdecurrent, narrow, crowded, "warm buff" to "pinkish buff" becoming "light ochraceous-buff" in age, a few forked, thin, becoming subpruinose, edge entire, concolor, stipe usually 3–9 cm long, 4–10 mm thick, equal or subventricose, concolor with pileus, hoary, becoming cavernous-hollow, milk white, unchanging, scanty, acrid, odor none, spores 8–10 × 7–8 μ, rough, basidia two- and four-spored, cystidia rather abundant, clavate, hyaline in young fruit-bodies Pinckney, Oct 10, 1931

This species is closely related to *Lactarius rufus* It is not infrequent during the late summer and fall in spruce bogs near Ann Arbor

LEPTONIA CHALYBAEA Fr — Pileus 1.5–3 cm broad, obtusely campanulate with a slightly depressed apex, innately fibrillose, not hygrophanous, not striate, evenly deep bluish black, dry, lamellae close to subdistant, very thin, adnate, seceding, not ventricose, tapering gradually to the margin, edge eroded and whitish, remainder a sordid watery blue, stipe 4–6 cm × 3–4 mm, concolor with pileus, covered by a faint layer of grayish fibrils, white-cottony at the base, often compressed, spores 7–10 × 5–7 μ, 5–6-angled, angles pronounced On soil, Lakeland No 32–414, Sept 14, 1932

LEPTONIA SUBSERRULATA Pk — Pileus 1–4 cm broad, margin incurved for a long time but finally expanding, center deeply

depressed, color white, becoming a pale grayish brown "light buff" near the margin, center darker, surface appressed-fibrillose, disk subscaly, appearing striate to the disk from the fibrils, not pellucid-striate, lamellae moderately broad, white, becoming flesh-colored, close to subdistant, rounded-adnate, edge eroded, concolorous at first but staining blackish when bruised, in age the margin of the pileus and gill edge are often stained black, stipe 4–6 cm × 2–3 mm, watery grayish, the apex pruinose, not punctate-dotted, white-cottony at base, pale watery grayish to nearly white above spores 8–10 (11) × 5–6 μ, sterile cells rare, clavate, slightly larger than the basidia This is a striking fungus because of the deeply depressed pileus, pale color, and the manner in which the lamellae stain It was collected on humus in a low woods at Lakeland No 32–412, Sept 14, 1932

NAUCORIA BELLULOIDES Kauff (Pl XL, Fig 1) — Kauffman (5) has described the spores of this species as "rough, dark rusty under the microscope" The writer found upon reëxamining the type that the spores were ochraceous, but otherwise as Professor Kauffman described them In the Michigan collections the spores were truly dark rusty Immature spores were also found in the same mounts, which resembled those of the type very closely, and it is probable that through some accident in the field the mature pilei in the type collection were not preserved The specimens in the type collection were on rotting wood During the spring and summer of 1932 this species was found to be very common on charred hummocks in a burned-over bog at Whitmore Lake Nos 32 9 (Joyce Hedrick), May 5, 1932, 32–32, May 30, 1932, 32–243, June 18, 1932

NAUCORIA CUCUMIS Fr — Pileus 2–3 5 (4) cm broad, campanulate, becoming repand, umbonate, "fuscous" or "chestnut-brown," fading to "fawn color," dry, pruinose-silky, corticated with a thick layer of dark rusty brown hyphae, tissue hyaline next to the lamellae, lamellae broadly adnate, becoming pruinose, stipe 3–4 cm × 2–4 mm, equal, slightly thicker upward, tough, elastic, pruinose to subvelvety, even, terete, chestnut-brown or fuscous throughout, spores 8–9 5 × 3–4 μ, narrowly oblong, obtuse, smooth, pale, cystidia 40–50 × 12–20 μ, broadly lanceolate, subventricose, or acuminate, smooth, hyaline, present on sides and edges, surface of pileus provided with similar cystidia

giving the pruinose appearance, basidia 25–28 × 5–6 μ, four-spored, odor slight, reminding one of fresh vegetables Collected June 25, 1929, on humus in a pine plantation near Ann Arbor The determination was made by Professor Kauffman and the description is taken from his notes The fungus was found again on July 7, 1932 (No 32–257), and Aug 17, 1932 (No 32–305) All the collections were made by the writer

NOLANEA DYSTHALES (Pk) Atk (Pl XXXVIII, Fig 2) — A large form (Pl XLI) was found in addition to typical specimens The pilei of the large form measured 2–4 cm broad and the stipe 7–10 cm × 7–9 mm In all other characteristics it was typical Nos 32–385, Sept 9, 1932, and 32–413, Sept 14, 1932, were of the typical form No 32–547, Oct 8, 1932, was of the large form All collections were from the vicinity of Ann Arbor

OMPHALIA INTEGRELLA Fr (Pl XLII) — This species is apparently very rare in Michigan The basidia were found to be two-spored, the spores measured 7 8 × 4–5 μ, and no cystidia were seen The whole plant is pure white, the flesh opaque, and the gills are veinlike The stipe is usually fibrous-dotted and the base slightly enlarged Collected on old pine bark, Ann Arbor Nos 32–254 and 32 254a, July 3, 1932

OMPHALIA MAURA Fr (*non* Ricken) (Pl XLIII, Fig 1) — The fruit bodies in the Michigan collection correspond to those of the species as described by Lange (7) The form described by Ricken (9) and reported by Kauffman (5) possesses a thick gelatinous pellicle, and cystidia were found on the sides and edges of the lamellae

OMPHALIA SPEIREA (Fr) Lange (Pl XLIII, Fig 2) — Pileus 5–10 mm broad, convex, becoming plane or with the margin elevated, not umbonate, fuscous on the disk, fading through drab and gray to whitish on the margin, glabrous, dry, striate, surface uneven, wrinkled radially, membranous, often widely plicate, lamellae adnate or adnate-decurrent, distant, grayish, edge concolor, interspaces venose, stipe short, 1–3 cm × 1–1 5 mm, pale gray or whitish, densely radiately strigose at base, not bulbose, becoming yellowish at base in age, spores 7 5–8 5 × 4–5 5 μ, basidia 23–26 × 5 μ, two-spored, sterile cells basidium-like, smooth Lange has placed this species in Omphalia and has described its variations very well The Michigan fungus is close

to *O tenuistipes* Lange, but that species is said to intergrade with *O speirea* Found scattered on small sticks in a low swamp, Stockbridge Nos 32-21, May 28, 1932, 32-543, Sept 21, 1932

PLEUROTUS CYPHELLAEFORMIS B & C Pileus 3-14 mm broad, 3-5 mm high, pendulous, vase-shaped, neither truly resupinate nor stipitate when young, point of attachment excentric, surface covered with minute white fibrous specks, then glabrous, viscid when mature, dark blackish gray at first, becoming lighter in age, large specimens slightly plicate-striate when expanded, lamellae narrow or moderately broad, distant, not meeting at a point but ending before they reach the base of the fruiting body (in large specimens sometimes growing down and meeting at a point as well as becoming rather ventricose), pale gray to whitish, entire surface of the inside of the pileus unicolorous, stipe none or a rather slightly elongated tubercle, pruinose or pubescent at times, spores allantoid, 7-8 × 2 5-3 μ, basidia four-spored, cystidia and sterile cells not seen, pileus trama of gelatinous hyphae often bearing clamp connections, gill trama slightly gelatinous On decaying stems of *Solanum Dulcamara*, Ann Arbor No 32-262, July 28, 1932

The margin of the pileus is inrolled at first and pruinose, as it expands the white particles often become arranged in concentric rows

TRICHOLOMA AURANTIUM Fr —This species has been found abundantly under spruce at Saginaw Forest, Ann Arbor, for the past two years Nos 10231, Oct 2, 1931, 32-474, Sept 23, 1932

TRICHOLOMA IMPOLITUM Fr —Pileus 5-10 cm broad, convex or slightly umbonate, dry, surface glabrous but appearing cottony, white when young, in age more creamy, often brownish on the disk, surface often cracking radially, margin recurved or inrolled for a long time, finally becoming plane, flesh thick, when bruised becoming "sulphur yellow" near the surface but not changing deep in the flesh, odor reminding one of fresh turnips, taste none or faint, lamellae narrow, crowded, slightly rounded-adnate, white, soon becoming "sulphur yellow" when bruised, stipe short and thick, 3-8 cm × 1-2 cm pure white, soon becoming "sulphur yellow" if handled, cottony at base, furfuraceous at the apex, clavate, becoming equal, spores 4 5 5 × 3-3 5 μ, oval, basidia two- and four-spored The stains on the pileus and

stipe ultimately become reddish tan Subcespitose to scattered, under oak First collected by Kauffman on Nov 7, 1926 Nos 71931, Oct 7, 1931, and 32–396, Sept 14, 1932, were collected by the writer

VOLVARIA LOVEIANA Berk (Pl XLIV) — This rare species has apparently been collected in only two localities in the region of the Great Lakes Dearness, 1896 (North Am Fungi, No 3509) found it near London, Ontario, and Harper (2), 1916, reports a collection which was sent to him from Minnesota

The writer's specimens were found growing parasitically on the fruit bodies of *Clitocbye nebularis*, and as a result the host fruiting bodies were quite contorted and deformed A few fairly typical specimens, however, enabled the writer to identify the host with certainty There seems to be some question whether or not the parasitic Volvaria is a distinct species or a parasitic form of a terrestrial species For a discussion of this question the reader is referred to Harper (2) and Maire (8)

UNIVERSITY OF MICHIGAN

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[illegible] A. H. Smith

PLATE XXXVIII

Fig. 1. *Collybia m[illegible]a* Fr. sensu Bresadola. ×1

Fig. 2. *Nolanea dysthales* (Pk.) Atk. Typical form. ×1

P AT XXXIX

lammula ca *ıa* F ×

PL

FIG 1 *Naucoria bellula* Kauff 1

FIG 2 *Inocybe paludinella* Pk 1

PLATE XII

Nolanea dysthales (Pk.) Atk. Large form. × 1

PLATE XLII

Omph... ...gell Fr. ... 1

PLATE XLIII

FIG. 1. *Omphalia maura* Fr. × 1

FIG. 2. *Omphalia speirea* (Fr.) Lange × 1

PLATE XLIV

Volvaria Loveiana Berk. × 1

THE FRESH-WATER ALGAE OF NEWFOUNDLAND *

PART I

WM RANDOLPH TAYLOR

INTRODUCTION

IN 1926 the writer was able to examine and contribute to a joint report upon a few vials of algae from Newfoundland (Taylor and Fogg, 1927) [1] In spite of the small amount of material, these samples suggested that the distribution of the phanerogam flora reported by Fernald (1911, 1918, 1929, 1933) might be paralleled by that of the fresh-water algae The collection of 1926 by John M Fogg, Jr, was supplemented in 1929 by two larger groups, one from the vicinity of St Johns by Miss Belle Burr, and the most extensive, one from the west coast by Bayard Long In view of our very limited knowledge respecting Newfoundland algae, practically consisting of only Cushman's short papers (1904, 1907) and some notes on diatoms and marine algae, the attractiveness of a study of these series was very great Apart from the importance of cataloging the algal population of any unexplored area, the peculiar character of the island multiplies its significance Fernald has discussed its unique character in supporting arctic and southern species among the expected boreal types, and has offered an explanation of the situation The central districts of the island are not represented in the present collections, all of which come from near the coast, but it is not anticipated that any large group of species would be restricted to the central area and so be missed on this account Localities from which collections are available may be grouped in four districts: the midwest of the northern peninsula, the midwest of

* Papers from the Department of Botany of the University of Michigan, No 408. A considerable part of this study was done at the Marine Biological Laboratory, Woods Hole, Massachusetts.

[1] The list of literature cited will be appended to Part II

the island as a whole, the south coast toward the west, and the southeast angle of the island That such sampling can really represent the whole flora or features of distribution with completeness is unthinkable, but there have resulted from the study a very surprisingly large list of species (the great bulk new for extreme northeastern America) and certain notable indications of local algal distribution

The writer acknowledges with the greatest pleasure the care of the collectors in bringing back these valuable samples For the first series descriptive notes on the district have already been published (Taylor and Fogg, 1927) The second series, collected by Miss Belle Burr about St Johns, is from the area most affected by man The third and largest series, brought by Bayard Long, was notably supported by data on habitats and phanerogamic associates Dr Fogg was of the party on this trip also, and gave the benefit of his algal experience Mr Long's extensive familiarity with the Newfoundland flora enabled selection of localities to be made with great effectiveness To Professor M L Fernald the writer has been indirectly indebted from the beginning, since two of the series were collected on expeditions directed by him and since the study was later fortified directly by his information and advice Dr Nellie Carter kindly examined a series of notes on the more troublesome desmids and in most helpful suggestions gave the advantage of her wide experience For generous and extensive help in many ways, especially in preparation of the new descriptions for publication, the writer is under great obligation to Professor H H Bartlett

Materials

The first series of Newfoundland algal samples, collected by John M Fogg, Jr, during the first fortnight in September, 1926, consisted of a very few vials Three samples came from the Bay of Islands (49° 10′ N L) on the west coast F 1, from wet sea cliffs on French Island, F 2, from a rill in an alder thicket on Woods Island, and F 3, from wet rocks of a serpentine ridge on the North Arm The other vials all contained samples from the neighborhood of Burgeo (47° 40′ N L) F 4–5, from wet gneissic ledges and F 6, from peaty slopes at Great Barachois, F 7, from a stream on a peaty slope and F 8 from a growth of Utricularia in a pool at Grandys

Brook, F 9, from a pool among gneissic rocks near Burgeo itself. A fuller description has been published (Taylor and Fogg, 1927).

The second series of collections was made by Miss Belle Burr (September 18–19, 1929) on the southeastern side of the island (47° 30′ N. L.), mostly in Bowring Park, near St. Johns. Collections B 5, 7, and 14 were attached to rocks or sticks in running water, B 9 and 20 were squeezed from moss, B 8, 11, 12, and 15 were attached to leaves or stonework in quiet water or pools, B 6 came from moss. Sample B 10 was scraped from shale above the level of standing water, B 17 and 19 were collected from damp soil, B 13 was scraped from a spring trough. The remainder of this group came from Whitbourne, southwest of St. Johns, and farther inland. From grass in pools or other quiet water came B 21, 23, and 26, B 24 was detached from a floating log. Sphagnum squeezings provided B 22 and 27, B 25 was scraped from an emersed rock, B 28 and 29 came from the surface of a ditch.

The third and most ample series of collections was made by Bayard Long between July and September, 1929. The most northerly series (112–136) was collected in late July and the first week of August on the northwest coast from about St. John and Ingornechoix bays (50° 40′ N. L.). The center of operations was Old Port-au-Choix, with collections from Pointe Riche and on St. John and Ingornechoix bays. A special group (113, 117, 118, 123, and 126) comprised green liquid from pitchered leaves of *Sarracenia purpurea*. From wet limestone sea cliffs came 120 and 121, the latter as gelatinous masses associated with *Cryptogramma Stelleriana* and *Thelypteris Robertiana*. Wet limestone rocks on the shore of a pond containing *Myriophyllum exalbescens* furnished 122. Rills on a peaty slope over limestone characterized by *Euphrasia disjuncta* provided 134, and turfy limestone barrens notable for *Salix reticulata* and *Pinguicula vulgaris*, 115. In limestone bog barrens there were many ponds, mostly with marl bottoms. One, having a vegetation marked by *Myriophyllum exalbescens* and *Potamogeton filiformis*, gave 116, others without (known) distinctive vegetation yielded 112, 114, and 119, 135 came from a marly quagmire pool supporting a growth of *Drosera linearis* and *Carex microglochin*. At Eddys Cove seepy runs over limestone margined by *Juncus albicans* provided 136. At Port-au-Choix sea cliffs on which grew *Salix calcicola* and *Arnica Griscomi* furnished 124 and 125, 127 came

from a pool above, with gelatinous masses on stones Doctors Hill afforded several samples, mostly from Deep Gulch Brook and its vicinity From rocks in a snow-fed brook containing *Veronica humifusa* came 128, a swift brook in close proximity to beds of *V humifusa* and *Epilobium Hornemanni* gave 132 On an ice-cold seepy slope with *E Hornemanni* and *Montia* was collected 129 On the hill summit a pond with quartzite boulders supported Sphagnum and a water moss, with gelatinous masses, 130 In spruce woods near the base of the hill green scum from a 'rising spring" and squeezings from moss in vegetation marked by *Catabrosa aquatica* gave 133

The second district represented by Long's August collections was the area of Bonne Bay (49° 20′ N L), nearer the middle of the west coast of Newfoundland On the Main (East) Arm at Tuckers Head, from seepy limestone cliffs near the sea, on which grew *Primula laurentiana* and *Arnica Fernaldii*, was secured 142, and in a similar situation at Stanleyville associated with *Polygonum viviparum* and *Tofieldia minima*, 139 On South Arm at Middle Brook in shallow backwater pools filamentous green matter was collected for 152, dripping slate and serpentine rocks about waterfalls at Shoal Brook bearing *Adiantum pedatum aleuticum* and *Cystopteris fragilis laurentiana* gave 138 a springy roadside ditch with *Sagina procumbens* and *Veronica americana* furnished 137 Lookout Mountain yielded bog material from about several ponds and pools, represented by collection 140 from a peaty pool with *Schizaea pusilla* and *Drosera anglica*, 145 with Chamaedaphne, Andromeda, and Drosera, 146 with Isoetes, and 147 with *Eleocharis palustris*, from about *Schizaea pusilla* and mosses with *Rhynchospora alba* and *Pogonia ophioglossoides* came small gelatinous masses, 141 From The Tableland, in an area of serpentine rock, material assembled from brooks and seepy rocky slopes was collected for 149, and from pools associated with *Eriophorum Chamissonis*, for 148 Sarracenia pitchers here afforded a green liquid, 150 Scattered stations in the area were the mouth of Wallaces Brook, where 144 was taken from seepy red shale cliffs, on which grew *Gentiana nesophila* and *Parnassia parviflora*, a brook from a spring within tide limits on Main River near Lomond, 151, and wet diorite cliffs near Western Head on the Gulf of St Lawrence, associated with *Oxyria digyna* and *Artemisia latisecta*, 143

Finally, a third group of Long's samples, collected in July, came from the Bay of Islands district, somewhat south of Bonne Bay, supplementing the Fogg series from the same area On Middle Arm material from Penguin Head (109) came from a seepy limestone cliff, from a rill in limestone with *Primula mistassinica* and *Polygonum viviparum*, 108, and from Cutwater Head, along a rill on cliffs of lime and slate, 111 The South Arm at Big Barachois gave more seepy limestone-cliff material, 110 Samples from McIvers Cove came from about the village 102 from ditches, 103 from wet spruce and alder thickets, and 104 from a seepy slate face with *Shepherdia canadensis* and *Draba arabisans* A number of collections were made near village centers up the Humber River at Petries (September) in a springy pool below a spruce-wooded slope, 153, at Curling (July) a film from boulders in a brook, 106, from slaty ledges bordering a swift brook, 107, and a springy railroad ditch (September), 154, Corner Brook (September) from a roadside ditch, 155, and from seepy depressions in turfy slopes with Juncus, 156, Humbermouth (July), from a flowing railroad ditch with *Linum catharticum* and *Mimulus moschatus* and farther above at Hannahs Head, a cold spring in limestone cliffs (July), 105

The proportions of different types found in the algal populations of Newfoundland must be surveyed very briefly Since limnoplankton samples were absent and scrapings from wet rocks were scantily represented, most of the collections came from bottom ooze or crusts or from among mosses or aquatic macrophytes Pure myxophycean associations were very infrequent Collection 106 yielded Phormidium from boulders in a brook, 110 Scytonema and 121 Gloeothece, from wet limestone cliffs. It is interesting to note that samples dominantly myxophycean, like 122 of Scytonema and 135 and 119 of mixed Chroococcaceae, graded from these in which desmids were secondary to samples like F 6, 8, and B 28, in which desmids were more important than the Myxophyceae In B 28 Closterium was a major item, but otherwise the desmid population was highly complex The material was principally derived from margins of pools

The genus Spirogyra was much more important than in the alpine regions of British Columbia (Taylor, 1928), but Mougeotia was rarely abundant In B 7, 101, 104, 149, 152, 155, and 156 sterile Spirogyra was dominant, without significant admixture, on

wet cliffs and in rills, streams, and ditches Zygnema held similar place in 138 and 154 Mougeotia in 134 filled a rill associated with a mixed unicellular flora, including many desmids, especially Cosmaria, Spirogyra in 136 dominated a desmid colony Some stations supported Zygnemataceae *in mixture*, as did 115, and these, too, (112 and 116) showed desmids in association Zygnemataceae-Desmidiaceae populations were richest in pools Desmidiaceae alone characterized the flora in some stations, as in B 25, 140, and 146, usually with numerous small Myxophyceae, and these, too, were from pond margins At 130 Microthamnion distinguished a mixed myxophycean-desmid flora in moss of a pool Ulothrix, 107, was abundant in a brook Oedogonia occasionally were dominant, fairly pure in B 5 and 153, but in B 20 and 103 they occurred with numerous desmids Rhizoclonium, too, appeared as a major floral element in 133, and in 120, scraped from a rock, with Myxophyceae Vaucheria was prominent in 132 and 142, fairly pure and probably forming marginal mats Botryococcus, 145, was dominant in a pool, with Dinobryon, Myxophyceae, and desmids Tribonema in B 14 was unaccompanied in 129 it was associated with a variety of desmids Diatoms dominated three samples Cymbella in 111 and 109, Diatoma in B 13, and Synedra in B 21 Synedra alone had a striking admixture of desmids Of more specialized floral elements there may be noted the Dictyosphaeria plankton in the Sarracenia pitchers mentioned in the station list, the Hydrurus population of streams at the localities for 128 and 131, and the Ophrydium with Chlorellae in 114, 127, 147 It is remarkable that no station (except that of the Sarracenia pitchers) was dominated by Protococcales and that the Myxophyceae played a relatively unimportant rôle In the formal list each numbered collection is ascribed to a correspondingly numbered collecting station, abbreviated "Sta"

Discussion and Distribution

Put as concisely as possible, Fernald's analysis of plant distribution on Newfoundland may be generalized as follows The rocks east of the Long Range Mountains and south of the northern peninsula tend to yield an acid soil, the crests and western slopes of the mountains are predominantly calcareous, with serpentine in some districts Respecting glaciation, it appears that the island

escaped the Pleistocene continental sheet, but had a local ice mass over much of the eastern part, the western summits underwent no extensive glaciation, and probably in a considerable degree were free of ice At present the eastern and east-central part of the island is cold and foggy under the influence of the arctic Labrador current, whereas the western slopes and shores are relatively warm and sunny, though the deep mountain valleys retain heavy accumulations of snow Many arctic, alpine, and contemporaneously Cordilleran vascular plants appear in the flora of the western border strip, the soil was favorable to them, and their colonies either antedated the Pleistocene ice and survived on unencumbered portions of the western ridge or became established as it retreated Many southern coastal plain (Carolinian) plants find northern limits in the south and southeast, because they are adapted to the sterile acid soil and reached it by a land bridge as the Pleistocene ice disappeared These two special classes of plants and a number of endemic species accent a flora the bulk of which is composed primarily of wide-ranging Boreal, and secondarily of Canadian-Alleghenian species, though it must be noted that the sterile soil appears to inhibit the growth of many species of these major elements which would otherwise be expected All but the northern peninsula lies below 50° N L, which barely traverses southernmost England, but the ameliorating effect of the Gulf Stream on English climate gives sharp contrast to the rigors imposed on Newfoundland by the Labrador current Soil, glaciation, and the opportunities for introduction, rather than climate, have determined the present-day distribution of the higher plants

The degree of segregation of characteristic desmid floras on Newfoundland cannot as yet be completely defined Lacking any contemporaneous and reasonably complete catalog of desmids of the world, with their distribution, one is thrown upon local floras Only that of the Wests and Carter (1904 23), for Great Britain, is sufficiently comprehensive in information and authoritative in presentation to be used as a guide, since for so small a study as the present it is obviously unprofitable to compile the necessary information from the widely scattered literature In making comparisons with the flora on the North American continent the situation is even worse In past years Europe and Great Britain have been stocked with poorly executed algal papers, but have come, through

the appearance of major monographs, to a tolerably accurate and fairly complete knowledge of their algal floras In America recovery from the indefatigable but superficial studies of Wolle, with their uncritical observations and incomplete, inaccurate illustrations, has not been effected With little more source material than the American texts of Wolle and the British texts of the Wests, a number of inexperienced investigators have proceeded to concoct lists purporting to represent the algal (particularly the desmid) floras of American districts, and, what is worse, to publish these naked of tangible proof of their accuracy, without adequate measurements, critical notes, or careful illustrations These simple lists rest for their authenticity solely upon the reputation of the author, and where this has not been established by the publication of thoroughly documented and illustrated preliminary studies, are of questionable value Usually there greets the reader no suggestion of the presence of anything foreign to the British flora, or of any variation beyond that illustrated in the Wests' monograph Actually — as the Wests and Smith have shown — an abundant and perplexing group of novelties and variants exists on the continent, of which many undoubtedly are as yet undescribed, failure to discern and record them is suggestive of superficial observation

The writer, uncomfortably aware that he himself may be open to condemnation for inadequate observation, has attempted so to illustrate and annotate the desmid portion of this text that here, at least, the aspect of his material will be clear to the reader He hopes that the errors which he cannot expect completely to avoid will be made clear to those with more experience and knowledge of the involved literature of the group With this digression in explanation of his failure to use American desmid literature in analysis of the Newfoundland flora, the writer may present the suggestions deriving from the material studied

By reference to Fernald's papers (1911, 1918, 1929, 1933) one perceives that climate and geology are somewhat in opposition in developing the Newfoundland flora Incursions from the coastal plain on the south and east find a suitable soil, but a cold, unfavorable climate On the north and west coast a relatively mild climate and calcareous soils are available to adventives from west and north, and the soil is more favorable to those from the north Professor Fernald was so kind as to prepare from his detailed field

experience a series of suggestions on the affinities of the phanerogamic floras of the several algal stations By use of these suggestions the writer tried by comparing the algal lists to segregate residues which would correspond to Fernald's lists (1911) of distinctive phanerogamic elements Unfortunately, our knowledge of the algae is too little advanced, the number of samples too few, and the presence of elements of a wide-ranging and undistinctive character too confusing to justify confidence in the results beyond certain very simple deductions Of the floristic elements suggested by Fernald the arctic, alpine, and cold north-temperate ones could not well be separated, nor could Hudsonian, Canadian, and wide-ranging North American types be unraveled, some idea of a Coastal Plain, or at least of a southern element, was possible, and of course the ubiquitous types were much as in other districts Separation of the floral elements will later be much more practicable, for as a meeting place of floras Newfoundland clearly affords unique research opportunities

If within the scope of this study one may venture to list species limited to a certain district, an example may be made of the area of Ingornechoix and St John bays Striking from the list species of known general distribution, we have left *Cosmarium alpestre, C binum, C decedens, C furcatospermum, C galeritum, C Hammeri homalodermum, C Holmiense* and var *integrum, C nasutum, C Pokornyanum, C speciosum* vars, *C subspeciosum, Euastrum insulare, E lapponicum, E montanum, Staurastrum borale,* and *S subcruciatum,* clearly a group very suggestive of arctic-alpine affinities There are many others primarily of this district, but scattered elsewhere as well, which are natural associates and which enhance the distinctiveness of the flora, in spite of the comparatively mild climate

One may justly expect that species of southern affinities would follow the phanerogams and appear in the southern district After one deducts from the Burgeo district list those from Whitbourne and St Johns there is a small residue which may possibly be significant *Pleurotaenium minutum, P rectum, Docidium undulatum, Staurastrum brachiatum, Euastrum cuspidatum, Micrasterias arcuata,* and *M speciosa* Furthermore, it is of interest that *M arcuata* and *M expansa* (described from Florida and also reported from Pennsylvania, New Jersey, and Massachusetts) occur in abundance near

Burgeo in association with *M conferta novae-terrae* and *Euastrum Allenı*, which Cushman described from Rose-au-Rue of Placentia Bay on the Newfoundland south coast However, Donat's suggestion that the large Staurastra are distributed from a southern center of dispersal is hardly in harmony with the fact that of all the samples studied the one from Station 140, Lookout Mt, alone showed a significant flora (ten species) of these types, which were practically absent from the stations along the southern coast, including Cushman's at Rose-au-Rue

Little conclusiveness can be ascribed to the list associated with the Canadian phanerogamic flora, for there are practically no published data from which to seek confirmation However, in Wailes's catalog (1925) of western British Columbia desmids also appear *Cosmarium subcrenatum*, *C taxichondrum*, *Staurastrum Arctiscon*, *S striolatum*, *Xanthidium cristatum uncinatum*, *Euastrum Didelta*, *E oblongum*, *E verrucosum*, *Micrasterias conferta*, *M radiosa*, *Spondylosium planum*, *Hyalotheca dissiliens*, and *H mucosa* These are wide-ranging species without marked tropical affinities

Finally, we may assemble the species which, on the island of Newfoundland, confirm their known habit of ranging widely in all climates The following list is associated with the south coast flora, with the arctic flora about Ingornechoix Bay, and usually with that at intermediate points *Cylindrocystis Brebissonii*, *Netrium Digitus*, *Closterium Venus*, *Cosmarium Botrytis* and vars, *C contractum*, *C granatum*, *C pyramidatum*, *C viride*, *Staurastrum dejectum*, *S dilatatum*, *S punctulatum*, *S setigerum*, *S teliferum*, *Euastrum binale* and vars, *E elegans*, *Tetmemorus Brebissonii*, *T laevis*, *Micrasterias truncata*, *Hyalotheca dissiliens* and var *hians*, and *Desmidium Aptogonum*

Another method of approach to the problem of distribution is by direct classification of the Newfoundland desmids according to the data given by the Wests and Carter (1904–23) For this study the genera *Cosmarium*, *Staurastrum*, *Euastrum*, and *Micrasterias* were selected Many species appear to have a distribution so irregularly scattered or so little known as to put them outside such an analysis, but nearly 130 species (selected irrespective of their Newfoundland range) did seem to yield pertinent data

We may assign 80 Newfoundland species to a group of widespread plants which generally cover a southern range In the

Burgeo area we find 27 of them with 35 station records, in the Whitbourne area (and St Johns), 32 species with 54 records, in the Bonne Bay area, 44 species with 62 records and in the Ingornechoix Bay area, 43 species with 99 records With the number of really notably rich desmid samples for these areas respectively 2, 2, 3, and 4 it will be seen that the distribution of those wide-ranging southern species which the British Isles and Newfoundland share, is not clearly distinctive on the island

If a similar comparison is made of the 30 wide-ranging species which have a distinct limitation to northern districts, we have a slightly different record The Burgeo area shows 7 species with 10 records, the Whitbourne, 6 species with 6 records, the Bonne Bay, 20 species with 25 records, and the Ingornechoix, 10 species with 19 records It is obvious that the proportion of these species to those of the last group is higher about Bonne Bay — because of two similar rich collections from Lookout Mt — and again distinctly lower about Ingornechoix Bay

Finally, discussing the types recorded as of a distinctly subarctic-arctic-alpine trend, we deal with 18 species, largely in Cosmarium The Burgeo area shows 3 species with 4 records, the Whitbourne, 2 species with 4 records, the Bonne Bay, 3 species with 3 records, and the Ingornechoix Bay, 16 species with 28 records Clearly, there is no special arctic-alpine component except about Ingornechoix Bay, but here we find it marked

Comparing these two sets of data we may conclude that the relatively sterile, acidic, and, in the east, colder southern stations support floras with species of broad range in mild climates, whereas the two main northwestern stations, with a relatively moderate climate and a more fertile soil derived from calcareous rocks, support floras with a distinctly more northern affiliation, which, about Ingornechoix Bay, includes a marked arctic-alpine element It is unfortunate that we do not have collections from the east central and northeast coasts The conclusions are so far in accord with the findings of Fernald respecting phanerogam distribution The desmids cannot be expected to yield as clear evidence as does the other group because their ranges are ordinarily wider than those of flowering plants and because we do not have adequate information respecting their American and south European distribution

List of Species[2]

MYXOPHYCEAE

CHROOCOCCACEAE

Aphanocapsa delicatissima W & G S West — Pools Stas 119, Ingornechoix Bay, 135, Pointe Riche[3]

Aphanocapsa elachista W & G S West — Wet moss Sta 141, Lookout Mt

Aphanocapsa fonticola Hansg — Pool Sta 112, St John Bay

Aphanocapsa paludosa Rabenh — Pool Sta 119, Ingornechoix Bay

Aphanocapsa pulchra (Kg) Rabenh — Pools Stas 116, St John Bay, 119, Ingornechoix Bay, 135, Pointe Riche

Aphanothece clathrata W & G S West — Pool Sta F 8, Grandys Brook

Aphanothece prasina A Br — Pools Stas 103, McIvers Cove, 135, Pointe Riche

Aphanothece saxicola Naeg — Wet cliff and pool Stas 120, Ingornechoix Bay, 135, Pointe Riche

Aphanothece stagnina (Spreng) A Br — Pools Stas 119, Ingornechoix Bay, 135, Pointe Riche

Chroococcus cohaerens (De Bréb) Naeg — Wet cliffs Sta 139, Stanleyville

Chroococcus dispersus (v Keissl) Lemm — Pools Stas 112, St John Bay, B 21, Whitbourne

Chroococcus limneticus Lemm — Pools Stas 112, 116, St John Bay

[2] Various circumstances have contributed to a somewhat unequal treatment of different algal groups. Since attention was concentrated on desmids early in the study, the other families were then less fully observed, and undoubtedly many inconspicuous elements were overlooked. Within the desmids Closteria were found exceptionally difficult of specific assignment, and many forms were omitted from lack of complete data Cosmaria and Staurastra were so abundant as isolated examples that many species of these genera undoubtedly were not noted Records by Cushman (1904, 1907) of species not noted by the writer are included without criticism

[3] It has seemed necessary to save space by extreme condensation of data on stations. By reference to pages 218–222, where numbers and names of stations are given, a more nearly complete description of the environment may be obtained.

CHROOCOCCUS MINOR (Kg) Naeg — Pool, cliff, and wet moss Stas 124, 140 (?), 141, St John Bay

CHROOCOCCUS MINUTUS (Kg) Naeg — Pools, wet cliffs, wet moss, and rills Stas 112, 116, 124, St John Bay, 130, Doctors Hill, 115, 119, Ingornechoix Bay, 134, 135, Pointe Riche 141, 146, Lookout Mt (abundant), 143, Western Head, 148, The Tableland, 103, McIvers Cove, 108, Penguin Head, F 9, Burgeo, B 26, 28, Whitbourne

CHROOCOCCUS TURGIDUS (Kg) Naeg — Pools, wet cliffs, wet moss, and rills Stas 112, 124, St John Bay, 130, Doctors Hill, 120, 134 (frequent), 135, Pointe Riche, 119 (frequent), Ingornechoix Bay, 139, Stanleyville, 145 (frequent), 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook, B 28 (frequent), Whitbourne

COELOSPHAERIUM KUETZINGIANUM Naeg — Pools Stas 116 (frequent), St John Bay, 122, Pointe Riche

COELOSPHAERIUM NAEGELIANUM Unger — Pools Stas 119, Ingornechoix Bay, 135, Pointe Riche, 140 (frequent), Lookout Mt

DACTYLOCOCCOPSIS IRREGULARIS G M Smith (var ?) — Cells isolated, without visible jelly, slenderly spindle-shaped, with delicate apices, arcuate, sigmoid, or once or twice spirally curved, the radii of curvature variable in different parts of the same cell, division planes obscure, apparently transverse, diameter 1 0–1 5 μ, length between ends 10–20 μ Closely resembling the Swedish plant described by Smith (1922) rather than *D rhaphidioides* Hansg, these specimens averaged but half as long Ditches Sta 102, McIvers Cove

GLOEOCAPSA ALPINA Naeg, *emend* Brand — Rills Sta 136, Eddys Cove

GLOEOCAPSA AMBIGUA Naeg — Pool and wet cliff Stas 112, St John Bay, 120, Pointe Riche

GLOEOCAPSA DERMATOCHROA Naeg — Pool Sta 119 (frequent), Ingornechoix Bay

GLOEOCAPSA MAGMA (De Bréb) Kg — Rills and wet cliff Stas 130, Doctors Hill, 143, Western Head, 149, The Tableland, 108, Penguin Head

GLOEOCAPSA MONTANA Kg — Pool Sta 135, Pointe Riche

GLOEOTHECE FUSCOLUTEA Naeg — Rills and wet cliff Stas 121, Ingornechoix Bay, 108, Penguin Head

GLOEOTHECE RUPESTRIS (Lyngb) Born — Pool Sta 135, Pointe Riche

GOMPHOSPHAERIA APONINA Kg — Rills and pool Stas 116, St John Bay, 119 (frequent), Ingornechoix Bay, 134, Pointe Riche

MERISMOPEDIA ELEGANS A Br — Pools Sta B 28, Whitbourne

MERISMOPEDIA GLAUCA (Ehrenb) Naeg — Pools Stas 130, Doctors Hill, 119, Ingornechoix Bay, 146, Lookout Mt, F 6, Great Barachois

MERISMOPEDIA PUNCTATA Meyen — Pools Stas 112, St John Bay, 122, 135, Pointe Riche, 119, Ingornechoix Bay, 140 (frequent), Lookout Mt, F 6, Great Barachois

MERISMOPEDIA TENUISSIMA Lemm — Pools Stas 112, 116, St John Bay, 122, Pointe Riche, 146, Lookout Mt, F 8, Grandys Brook, B 26, Whitbourne

MICROCYSTIS AERUGINOSA Kg — Pools and rill Stas 112, 116, St John Bay, 119, Ingornechoix Bay, 134, Pointe Riche

MICROCYSTIS FLOS-AQUAE (Wittr) Kirchn — Pool Sta B 26, Whitbourne

RHABDODERMA LINEARE Schmid & Lauterb — Pools Stas 112, 116, St John Bay, 122, Pointe Riche, 145, 146 (frequent), Lookout Mt, F 8, Grandys Brook

SYNECHOCOCCUS AERUGINOSUS Naeg — Pools Stas 130, Doctors Hill, 122, 135, Pointe Riche, 119, Ingornechoix Bay, F 6, Great Barachois

CHAMAESIPHONACEAE

CHAMAESIPHON INCRUSTANS Grun — Stream Sta 151, Lomond

OSCILLATORIACEAE

HYPHEOTHRIX CALCICOLA Rabenh (?) — Pool, wet cliff, and in wet moss Stas 120, 135, Pointe Riche, 141, Lookout Mt

LYNGBYA AERUGINEOCAERULEA (Kg) Gom — Pool Sta 135, Pointe Riche

LYNGBYA RIVULARIARUM Gom — Wet moss Sta 141, Lookout Mt

OSCILLATORIA FORMOSA Bory — Ditch and spring Stas 102, McIvers Cove, 105 (frequent), Humber River

OSCILLATORIA IRRIGUA Kg — Pools Sta F 9 (frequent), Burgeo

OSCILLATORIA SPLENDIDA Grev — Wet cliff Sta 125 (abundant), Port-au-Choix

OSCILLATORIA SPP — Wet rocks and wet cliff, ditch and pool Indeterminable material of this genus was not very prominent in these samples Stas 102 (4–5 μ in diameter), McIvers Cove, 125 (4 3 μ), 132 (5 6 μ), St John Bay, 138 (1 8 μ), Shoal Brook, B 21, Whitbourne

PHORMIDIUM AUTUMNALE (Ag) Gom — Brook Sta 106 (major item), Curling

PHORMIDIUM LAMINOSUM (Ag) Gom — Wet cliff Sta 109, Penguin Head

SCHIZOTHRIX FUSCESCENS Kg — Wet moss Sta 141, Lookout Mt

SCHIZOTHRIX MUELLERI Naeg (?) — Wet moss Sta 141, Lookout Mt

NOSTOCACEAE

ANABAENA MINUTISSIMA Lemm — Wet moss Sta 141, Lookout Mt

ANABAENA SPP — Cliff, ditch, and pool Stas 102, McIvers Cove, 145 (3 8–4 5 μ in diameter), Lookout Mt, 103 (5 6 μ in diameter), McIvers Cove

ANABAENA SP — Trichome flexuous, diameter 5 5–6 0 μ, cells 6 5–8 5 μ long, barrel-shaped, heterocysts 6 0 μ in diameter, 11 3 μ long, spores 9 5 μ in diameter, 50–65 μ long, remote from the heterocysts These plants do not agree with the description of any familiar species, particularly in their extraordinary spore length, but they were too few to justify more than incidental mention

CYLINDROSPERMUM STAGNALE (Kg) Born & Flah (?) — Sta 103, McIvers Cove

NOSTOC COMMUNE Vauch — Wet cliff and pool Stas 124, St John Bay, 135 (abundant), Pointe Riche

NOSTOC SP — Wet rock face Sta F 3, North Arm

SCYTONEMATACEAE

SCYTONEMA ALATUM (Carm) Borzi — Pool Stas 122, 135 (major item), Pointe Riche

SCYTONEMA MYOCHROUS (Dillw) Ag — Pools, wet cliffs, wet moss,

and rills Stas 119, Ingornechoix Bay, 122 (major item), 135, Pointe Riche, 141, 146, Lookout Mt, 108, Penguin Head, 110 (major item), South Arm, F 8, Grandys Brook

TOLYPOTHRIX DISTORTA var PENICILLATA (C Ag) Lemm — Pools Stas 119, Ingornechoix Bay, 122, Pointe Riche

TOLYPOTHRIX TENUIS Kg — Pools Stas 135, Pointe Riche, 148, The Tableland

STIGONEMATACEAE

HAPALOSIPHON HIBERNICUS W & G S West — Wet moss Sta 130, Doctors Hill

HAPALOSIPHON INTRICATUS W West — Wet moss and pool Stas 130, Doctors Hill, 141, Lookout Mt

HAPALOSIPHON LUTEOLUS W & G S West — Pools and wet moss Stas 130, Doctors Hill, 145 (frequent), Lookout Mt, F 8, Grandys Brook

STIGONEMA INFORME Kg — Pool Sta 135, Pointe Riche

STIGONEMA MAMILLOSUM (Lyngb) C Ag — Pool Stas 112, St John Bay, 122, Pointe Riche

STIGONEMA MINUTUM (Ag) Hass — On wet moss Sta 130, Doctors Hill

STIGONEMA OCELLATUM (Dillw) Thuret — Wet rocks, cliffs, and moss, pool Stas 141, Lookout Mt, 148, 149, The Tableland, 143, Western Head, F 6, Great Barachois, F 8, Grandys Brook

STIGONEMA TURFACEUM Cooke — Wet moss Sta 141, Lookout Mt

RIVULARIACEAE

CALOTHRIX PARIETINA (Naeg) Thuret — Wet cliffs and rocks, rills and pool Stas 119, Ingornechoix Bay, 120, Pointe Riche, 139, Stanleyville, 143, Western Head, 108, 109, Penguin Head, F 3, North Arm Other Calothrixes were noted, but were too sparsely represented to make determinations possible

DICHOTHRIX GYPSOPHILA (Kg) Born & Flah — Pool Sta 119, Ingornechoix Bay

LEPTOCHAETE RIVULARIS Hansg (?) — Cliff Sta 120, Pointe Riche The trichomes were rather slender and long (to 40 μ) for this species

GLAUCOCYSTIDACEAE

GLAUCOCYSTIS NOSTOCHINEARUM Itzigs — Pool Sta B 21, Whitbourne

CHLOROPHYCEAE

VOLVOCACEAE

EUDORINA ELEGANS Ehrenb — Ditch and pools Stas 102 (abundant), McIvers Cove, B 26 (frequent), Whitbourne

GONIUM PECTORALE Muell — Ditch Sta 102 (frequent), McIvers Cove

PANDORINA MORUM (Muell) Bory — Ditch and pools Stas 102, McIvers Cove, B 26 (frequent), Whitbourne

TETRASPORACEAE

ASTEROCOCCUS SUPERBUS (Cienk) Scherf — Wet cliff and pools Stas 142 (abundant), Tuckers Head, B 26, Whitbourne A small form (15–22 μ in diameter) with several chromatophore rays and lamellose sheath, 1–4 cells to a colony

DICTYOSPHAERIUM PULCHELLUM Wood — Stas 113, 117, 118, 126, St John Bay, 123, Eastern Point, 150, The Tableland Abundant at all stations in the liquor-filled pitchered leaves of *Sarracenia purpurea* The plant appeared as reduced colonies of rarely more than four cells, held together by the characteristic strands, there were no large colonies, and the gelatinous envelope (in the formalin samples) was not evident The cells were rather small, reaching 5 5 μ before dividing, and were slightly elongated, as Smith (1924) figures, rather than as found in *D Ehrenbergianum* Naeg Similar reduced forms are reported in water bloom of ponds The microscopic aspect of the material and its great abundance, coloring the water deeply, emphasize the curious habitat and suggest that the quiet, warmed water and increased nitrogen supply may have greatly stimulated multiplication

GLOEOCYSTOPSIS LIMNETICUS G M Smith — Pool Sta 116, St John Bay

TETRASPORA LUBRICA (Roth) Ag — Ditch Sta 102 (abundant), McIvers Cove

CHLOROCOCCACEAE

CHARACIUM BRAUNII Brueg — Wet moss Sta 130, Doctors Hill
CHARACIUM FALCATUM Schroed — Ponds Sta F 9, Burgeo

HYDRODICTYACEAE

PEDIASTRUM BORYANUM (Turp) Menegh — Pools Sta 116, St John Bay, B 26, Whitbourne

PEDIASTRUM BORYANUM var LONGICORNE Racib — Pools Stas 116, St John Bay, F 9 (frequent), Burgeo, B 6, 18, St Johns, B 26, Whitbourne

PEDIASTRUM DUPLEX Meyen — Pools Sta F 9, Burgeo, B 26, Whitbourne

PEDIASTRUM INTEGRUM Naeg — Pools and rills Stas 115, Ingornechoix Bay, 122, 134, Pointe Riche

PEDIASTRUM TETRAS (Ehrenb) Ralfs — Ponds Stas F 9, Burgeo, B 24, 26, Whitbourne

PEDIASTRUM TETRAS var TETRAODON (Corda) Ralfs — Pools Stas 116, St John Bay, 146, Lookout Mt, F 9, Burgeo, B 21, Whitbourne

OOCYSTACEAE

CHLORELLA VULGARIS Beyer — Pool Sta 147, in *Ophrydium problematicum*, Lookout Mt

EREMOSPHAERA VIRIDIS De Bary, exceeding var MAJOR Moore — Sta B 28, Whitbourne These plants were too large for the variety described by Moore (1901), which measured 67–105 μ in diameter, since the range for the Newfoundland samples was 103–192 μ He referred to the existence of larger forms in other localities However, there is justification for nothing more than a suggestion that the size limits for the species in America are hereby increased

PARVA W & G S West — Pool Sta 145, Lookout Mt

SOLITARIA Wittr — Wet moss Sta 130, Doctors Hill

TETRAEDRON MINIMUM (A Br) Hansg — Pool Sta B 26, Whitbourne

TETRAEDRON REGULARE var BIFURCATUM Wille — Pool Sta 119, Ingornechoix Bay

TETRAEDRON TRIGONUM (Naeg) Hansg — Stas 146 (small f), Lookout Mt, B 26, Whitbourne

COELASTRACEAE

ANKISTRODESMUS FALCATUS (Corda) Ralfs — Ditch, pools, and wet cliff Stas 116, St John Bay, 119, Ingornachoix Bay, 142, Tuckers Head, 102, McIvers Cove F 9, Burgeo, B 6, 9, 18, St Johns, B 21, Whitbourne

ANKISTRODESMUS FALCATUS var MIRABILIS W & G S West — Pools Stas 134, Pointe Riche, B 24, 26, Whitbourne

ANKISTRODESMUS FALCATUS var TUMIDUS (W & G S West) G S West — Pools Stas B 21, 26, Whitbourne

COELASTRUM CAMBRICUM Archer — Pool Sta 122, Pointe Riche

COELASTRUM MICROPORUM Naeg — Pool Sta F 9 (frequent), Burgeo

CRUCIGENIA IRREGULARIS Wille — Pool Sta 116, St John Bay

QUADRIGULA CLOSTERIOIDES (Bohlin) Printz (f) — Pool Sta 140, St John Bay

These plants (although slender) agreed with the figure in Strøm (1926) for his *Q montana*, but Printz (1927) merges this species with his *Q closterioides*, presumably as a slender form The Newfoundland plants showed cells 24–26 μ long and as much as 2 μ in diameter

SCENEDESMUS ACUTIFORMIS Schröder — Pool Sta B 26, Whitbourne

SCENEDESMUS ARMATUS (Chod) G M Smith — Pool Sta F 9, Burgeo

SCENEDESMUS BIJUGUS (Turp) Lagerh — Ditches Sta 102 (frequent), McIvers Cove

SCENEDESMUS BIJUGUS var ALTERNANS (Reinsch) Borge — Pools and wet thicket Stas 140, Lookout Mt, 103, McIvers Cove, B 6, 18, St Johns, B 21, Whitbourne, frequent

SCENEDESMUS BRASILIENSIS Bohlin — Pools Stas B 6, 18, St Johns, B 24, Whitbourne

SCENEDESMUS DENTICULATUS Lagerh — Pools Stas 119, Ingornachoix Bay, 146, Lookout Mt, F 9, Burgeo

SCENEDESMUS DIMORPHUS (Turp) Kg — Pool Sta B 21, Whitbourne

SCENEDESMUS OBLIQUUS (Turp) Kg — Pools and wet thicket Stas 102, 103, McIvers Cove, B 18, St Johns

SCENEDESMUS QUADRICAUDUS (Turp) De Bréb — Pools Stas B 21, Whitbourne, F 9, Burgeo

SELENASTRUM MINUTUM (Naeg) Collins — Pools, a spring, and wet moss Stas 130, Doctors Hill, 122, Pointe Riche, 140, Lookout Mt , 101, Humbermouth

SELENASTRUM WESTII G M Smith — Ditches Sta 102, McIvers Cove

SORASTRUM SPINULOSUM Naeg — Pool Sta 122, Pointe Riche

ULOTRICHACEAE

GEMINELLA INTERRUPTA Turp — Pool Sta 148, The Tableland

MICROSPORA QUADRATA Hazen — Rills Sta F 2, Wood Id

ULOTHRIX VARIABILIS Kg — Rills and pool Stas F 2, Wood Id , F 9 (?) (major element), Burgeo

ULOTHRIX ZONATA (Web & Mohr) Kg — Brook Sta 107 (major element), Penguin Head

CHAETOPHORACEAE

DRAPARNALDIA PLUMOSA (Vauch) Ag — Ditch Sta 102 (abundant), McIvers Cove

MICROTHAMNION KUETZINGIANUM Naeg. — Moss in pool Sta 130 (frequent), Doctors Hill Filaments rather slender, little over 3 μ in diameter, but the habit is quite characteristic

MICROTHAMNION KUETZINGIANUM var **congestum,** var nov [4] — Plants branching below as in the species, but the upper branches more erect or less spreading, forming a particularly dense tuft and developing some distinction of main axes, diameter of lower cells 2 0–2 5 μ, length 6–10 μ, diameter of uppermost

[4] *Microthamnion Kuetzingianum* Naeg var congestum, var nov — Plantae ut videtur 100–150 μ altae, inferiore parte ramosae ut in f *typica*, sed ramis partium superiorum valde erectis vel minus patentibus, dense congestis, axibus primariis etiam quam sequentibus valde distinctis, cellulis inferioribus 2 0–2 5 μ diamentientibus, 6–10 μ longis, superioribus ca 1 5 μ diametro, plerumque 15–20 μ longis sed frequenter 35 μ. Newfoundland, in loco dicto Doctors Hill frequens; legit Bayard Long Specimen typicum in Herb Univ Mich conservatum

cells about 1 5 μ, length generally 15–20 μ, frequently reaching 35 μ, height of plant 100–150 μ in detached specimens seen

It was not altogether easy to determine the limits of the proposed variety and the species in the small form recorded, but in the latter the spreading irregular branching was maintained throughout, and the ultimate cells were neither much longer nor more slender than those below It differs from *M strictissimum* in size and density of branching, and from *M exiguum* Reinsch in density of branching and the subtapering (as opposed to subclavate) terminal cells Sta 130 (frequent), Doctors Hill

MICROTHAMNION STRICTISSIMUM Rabenh — Wet moss in pool Sta 130 (rare), Doctors Hill

CHAETOPELTIDACEAE

CHAETOSPHAERIDIUM GLOBOSUM (Nordst) Klebh — Pools Stas 116, St John Bay, 135, Pointe Riche, 140, Lookout Mt , F 8, Grandys Brook, B 26 (frequent), Whitbourne

COLEOCHAETACEAE

COLEOCHAETE IRREGULARIS Pringsh — Pool Sta B 26, Whitbourne

COLEOCHAETE SCUTATA De Bréb — Pool Sta 116, St John Bay

COLEOCHAETE SOLUTA Pringsh — Pool Sta B 26, Whitbourne

OEDOGONIACEAE

BULBOCHAETE SPP — Pools Stas 112, 116, 135, 146, F 8, except the first two stations, abundant It is rather surprising that no fruiting plants were obtained

OEDOGONIUM SPP — Stas 116, two species, 122, 140, 145, 146, four species, 103 (major item), 153, 101, F 8, F 9, B 5 (major item), B 20, B 21, two species No material showed even immature fruit in any abundance

CLADOPHORACEAE

CLADOPHORA SP — Brook near the sea Sta. 151, Lomond, filament diameter 34 μ below, 22 μ near the apex

RHIZOLONIUM HIEROGLYPHICUM (Ag) Kg — In a spring and on a wet cliff Stas 120, Pointe Riche, 133, Doctors Hill, the major item in each collection

VAUCHERIACEAE

VAUCHERIA BOREALIS Hirn — Sta 132 (major item), Doctors Hill

VAUCHERIA SESSILIS (Vauch) DeC — Wet cliff Sta 142 (major item), Tuckers Head

VAUCHERIA SPP — Ditch and pools Stas 137, Shoal Brook, B 20 (abundant), St Johns, sterile

ZYGNEMATACEAE

MOUGEOTIA CALCAREA Wittr — Rills Sta 134, Pointe Riche, the *major item and in fruit Some of the stations involving sterile* filaments of Mougeotia 10–14 μ in diameter probably also support this species

MOUGEOTIA QUADRANGULATA Hass — Sta 102, McIvers Cove

MOUGEOTIA SPP — Stas 114, 116, 124, three species, 115, two species, 138, two species, 139, 143, two species, 145, 146, 148, with young zygospores, 152, 108, 109, two species, 101, 105, F 4, F 7, F 8, two species In many cases sterile Mougeotia was a prominent, or even the dominant, element in the flora, for no account is taken here of samples with sporadic filaments The material may be divided into at least eight groups of species on the basis of cell size This indicates that there are several species of Mougeotia prominent as constituents of the flora

SPIROGYRA VARIANS (Hass) Kg — Wet cliff Sta F 1, French Id , sparsely fruiting, but a major item

SPIROGYRA SPP — Stas 112, 116, 124, 125, four or five species, 115, 134, three species, 137, 138, two species, 139, 144, 140, 146, 149, 152, 102, with immature lateral conjugation, 108, 155, 101, 105, 104, F 8, B 7, B 21, 23 In many of these stations sterile Spirogyra was a prominent, or even the dominant, element, and it is notable that it was found so seldom in fruit, this condition being generally true of cold northern or alpine situations Inspection of the recorded data suggests that the species present divide into seven groups on the basis of size of

cells, but the differences in structure of septa and number of chromatophores increase this total There were no specimens with more than three chromatophores

ZYGNEMA PECTINATUM (Vauch) C Ag var DECUSSATUM (Vauch) Kirchn — Sta 112, St John Bay

ZYGNEMA SPP - Stas 112, 114, 116, 124, perhaps four species, 115, two species, 134, 138, 139, 141, 143, 144, two species, 148, 149, five species, 102, 108, 110, F 3, F 4, B 21, 23, 24, two species These sterile collections did not segregate readily into interpretable size classes

DESMIDIACEAE

MESOTAENIUM Naegeli

MESOTAENIUM DEGREYII Turn —Reported by Cushman (1907) from St Anthony

MESOTAENIUM ENDLICHERIANUM Naeg — Reported by Cushman (1907) from Rose-au-Rue

MESOTAENIUM MACROCOCCUM (Kg) Roy & Biss — L [5] 30–34 μ, w 15–18 μ Wet cliff and wet moss Stas 130, Doctors Hill, 110, South Arm (numerous, in jelly)

ROYA W & G S West

ROYA OBTUSA (De Bréb) W & G S West, near var MONTANA W & G S West (Pl XLV, Fig 1) — L 55 62 μ, w 6 0 7 5 μ Ditches and wet moss Stas 102, McIvers Cove, B 6, Bowring Park Probably the plant shown in Pl XLVI, Fig 17, is also to be referred here

CYLINDROCYSTIS Menegh

CYLINDROCYSTIS AMERICANA W & G S West (Pl XLV, Fig 9) — L 53–58 μ, w 22 5–26 μ Seepy slope and ditch Stas 129, Doctors Hill, B 27 (frequent), Whitbourne

[5] The following abbreviations are used throughout this part of the text l = length, the greatest axial extent of the cell in straight species, with apical notches and spines disregarded and in curved species the chord of the arc extended to equal the greatest projection of the cell ends, w = width, th = thickness, isth = isthmus from face view Except where measurements were of particular interest, no attempt was made to secure them from many individuals of a species.

Cylindrocystis americana var minor Cushm — Reported by Cushman (1907) from Rose-au-Rue

Cylindrocystis Brebissonii Menegh (Pl XLV, Figs 6–7) — L 47–65 μ, w 14–22 μ Seepy slopes and rills, ditch Stas 129, Doctors Hill, 102, McIvers Cove, F 2, Wood Island (frequent), F 6, Great Barachois, F 8, Grandys Brook, B 22, 24, 26, 27 Whitbourne (from some stations frequent)

Cylindrocystis Brebissonii var minor W & G S West (Pl XLV, Fig 5) — L 28–35 μ, w 13 μ Ditch and wet moss Stas 141, Lookout Mt , 102, McIvers Cove, B 27, Whitbourne

Cylindrocystis crassa De Bary (Pl XLV, Fig 10) — L 48–64 μ, w 21–22 μ Seepy slope Sta 129, Doctors Hill

Cylindrocystis diplospora Lund (Pl XLV, Fig 8) — L 68–72 μ, w 32–38 μ, isth 28–32 μ Pool Sta 112, St John Bay

Spirotaenia De Bréb

Spirotaenia condensata De Bréb (Pl XLV, Fig 25) — L 110–136 μ, w 17–19 μ Pools Stas 129, Doctors Hill, 146, Lookout Mt

Spirotaenia sp — Cell large, distinctly tapering toward the rounded ends, chromatophore broad, with 3 (or more?) loose turns and 3–4 pyrenoids L 75 μ, w 11 5 μ On log in stream Sta B 24, Whitbourne

Netrium Naegeli

Netrium Digitus (Ehrenb) Itzigs & Rothe (Pl XLV, Figs 3–4) — L 122–219 μ, w 32–65 μ Pools, rills, ditches, and wet moss. Stas 112, St John Bay, 119, Ingornechoix Bay, 135, Pointe Riche, 136, Eddys Cove, 129, 130, Doctors Hill, 145, 146, Lookout Mt , 148, The Tableland, F 6, Great Barachois, F 8, Grandys Brook, B 6–20, St Johns, B 21, 22, 27, 28, Whitbourne

Netrium oblongum (De Bary) Lütkem — L 156 μ, w 34 μ Pools Sta F 6, Great Barachois

Netrium oblongum var cylindricum W & G S West (Pl XLV, Fig 2) — L 65 μ, w 19 μ In wet moss. Sta 130, Doctors Hill

Gonatozygon De Bary

Gonatozygon aculeatum Hastings (?) (Pl. XLVII, Fig 14) — Cells forming cylindrical filaments, individual cells subcylindrical,

slightly contracted from below the apex toward the center, ends truncate, margin very slightly rounded, membrane abundantly beset with long spines, chromatophore an axile plate with about 6–10 pyrenoids L 130–150 μ, w at center 18 18 5 μ, w at poles 19 5 μ, l spines about 10 12 μ Pools Sta 146, Lookout Mt A filament of thirty cells was traced This plant is slightly wider than the f *minor* W & G S West, and has longer spines Johnson (1895) figures *G aculeatum* as l 300 μ, w 16 μ, spines 6 8 μ, but Smith (1924 *b*) had, according to his Figure 1 of Plate 13, a short-celled plant The original figure by Hastings (1892) shows rather shorter and stouter spines than does that of the present writer, with the cell ends slightly more capitate and relatively longer (estimated length 200 μ, diameter over spines 40 μ)

Gonatozygon Brebissonii De Bary — Pools Stas 122, Pointe Riche, 148, The Tableland

Gonatozygon Kinahani (Arch) Rabenh — L 182 μ, w at center 10 5 μ, w at poles 11 5 μ, cell smooth Pool Sta B 21, Whitbourne

Gonatozygon Kinahani var **majus**, var nov [6] (Pl XLVII, Fig 13) – Individual cells cylindrical, straight or slightly curved, ends flattened to slightly curved, polar angles rounded, very faintly contracted below the poles and more slender in the center, wall smooth, chromatophore broad, compressed, flat to twisted, constricted near the center of the cell, with many pyrenoids dispersed through the band L 447–759 μ, w at center 24–32 μ, w at poles 28–36 μ Pond Sta 146 (quite frequent), Lookout Mt

This plant suggests *G Kinahani* except for its much greater size and different disposition of the pyrenoids Since Gonatozygon filaments are particularly fragile, it is quite usual to find the cells disattached, as was generally the case in this material The average cell length was 610 μ, cell diameter 28 μ, and polar diameter 33 μ Grönblad (1920) assigns a very similar

[6] *Gonatozygon Kinahani* (Arch) Rabenh var **majus**, var nov — Cellulae cylindricae, rectae vel subcurvatae, apicibus planis vel curviusculis, angulis polaribus rotundatis, inconspicue prope pola contractae et ad medium paululo angustatae, membrana laevi, chromatophoro lato compresso plano vel torto prope cellulae medium constricto, somatibus pyrenoideis multis, dispersis Long 447–759 μ, lat med 24–32 μ, lat pol 28–36 μ Newfoundland, in loco dicto Lookout Mt legit Bayard Long

form to *G Kinahani*, with an expression of doubt, his plant (l 228–562 μ, w at center 21 μ, w at poles 23 μ) is smaller and distinctly more slender than the present form It seems better to segregate the Newfoundland material, particularly since more nearly normal *G Kinahani* is also found on the island

GONATOZYGON MONOTAENIUM De Bary (f) — L 300–420 μ, w at center 13–16 μ, w at poles 15–18 μ Pool Sta 112, St John Bay

Except for greater maximum size these data agree well with the description of the species, Smith (1924) reports it as nearly as large

GONATOZYGON PILOSUM Wolle — L 113–215 μ, w at center 10–12 μ, w at poles 11 5–12 μ, spines close, short, and sharp Pool Sta 130 (frequent), Doctors Hill

PENIUM De Bréb

PENIUM CRUCIFERUM (De Bary) Wittr (Pl XLV, Fig 16) — L 20–30 μ, w 13–15 μ Ditch and seepy slope Stas 129, Doctors Hill, 102, McIvers Cove

PENIUM CYLINDRUS (Ehrenb) De Bréb — L 58 μ, w 135 5 μ, wall brown, rather irregularly granulate Ditches Sta 102, McIvers Cove

PENIUM POLYMORPHUM Perty (Pl XLV, Fig 17) — L 57 μ, w 21 μ Pool Sta 130, Doctors Hill

PENIUM SPIROSTRIOLATUM Barker (Pl XLVII, Fig 12) — L 290–317 μ, w at center 14–19 μ, w max 21 μ, w at poles 16–18 μ Pools Stas 130, Doctors Hill, B 21, Whitbourne

CLOSTERIUM Nitzsche

CLOSTERIUM ABRUPTUM W West (Pl XLVI, Fig 9) — L 150–207 μ, w 14–15 μ Ditches Sta 102 (frequent), McIvers Cove

Material from Sta 146, Lookout Mt, rather long and narrow (122 μ × 10 3 μ), had the contour of this species, but too many pyrenoids

CLOSTERIUM ACEROSUM (Schrenck) Ehrenb (Pl XLV, Fig 20) — L 415–530 μ, w 42–45 μ Ditches Stas 103, McIvers Cove, 101, Humbermouth

CLOSTERIUM ACEROSUM var ELONGATUM De Bréb (Pl XLV,

Fig 23) — L 654 μ, w 42 μ Ditches Stas 137, Shoal Brook, 103, McIvers Cove

Material from Sta 137 approached the species in dimensions

CLOSTERIUM ANGUSTATUM Kg — L 439 μ, w 22 μ Pool Sta F 9, Burgeo

CLOSTERIUM near ARCHERIANUM Cleve (Pl XLVI, Fig 10) — L 305 μ, w 30 μ, wall brown, faintly and broadly striate, and possibly very finely porose, ends darker and finely porose Pool Sta F 8, Grandys Brook

Resembling this species in shape, but rather longer and more broadly striate, with faintly truncate apices

CLOSTERIUM CORNU Ehrenb (Pl XLVI, Fig 8) — L 103 μ, w 6 μ Pool Sta 146, Lookout Mt Specimens generally were a little small for this species

CLOSTERIUM COSTATUM Corda var WESTII Cushm (Pl XLVIII, Fig 1) — L 315 μ, w 32 μ, w at apex 11 3 μ Pool Sta B 8, Grandys Brook

This agrees quite well with the description of var *Westii* in Cushman (1905), Borge (1909) describes slightly smaller plants from Halifax, Nova Scotia

CLOSTERIUM CYNTHIA De Not — Reported by Cushman (1907) from St Anthony

CLOSTERIUM DIANAE Ehrenb var (Pl XLVI, Fig 3) — L 103–115 μ, w 17 μ, wall pale yellow Wet moss Sta B 6, St Johns

CLOSTERIUM DIDYMOTOCUM Ralfs (f) (Pl XLV, Fig 19) — L 280–455 μ, w 30 43 μ, apex 13–15 μ, wall brown with darker, very slightly thicker ends, intercalary segments usually present, wall weakly to strongly striate, 18–23 striae across the cell (about 6 striae per 10 μ), intervals between striae, and apex, minutely punctulate Ditches and pools Stas 102, McIvers Cove, B 20, St Johns, B 26, 28 (major item), Whitbourne

The Wests (1904) somewhat hesitatingly and Cushman (1908) very clearly refer to striate forms of *C didymotocum* Corda Lowe (1923) describes a *C didymoctocum* var *striatum*, which has some points of resemblance to the Newfoundland plants, but which is inadequately differentiated from the species Grönblad (1919) segregates material with intercalary segments and striate walls under the name given above, with the rest as *C Baillyanum* De Bréb His data call for a broader, less tapered cell,

with more numerous striae than the plants at these Newfoundland stations

CLOSTERIUM EBORASCENSE Turn (Pl XLVI, Fig 13) — L 213-220 μ, w 42-49 μ Ditches and wet moss Stas 102, McIvers Cove, B 6, 20, St Johns

CLOSTERIUM GRACILE De Bréb (Pl XLVI, Fig 7), var (Pl XLVI, Fig 16) — L 206 μ, w 4 3 μ Pool Sta 146, Lookout Mt

Slightly long for the species, but far too small for var *elongatum* W & G S West The plant in Figure 16 (1 130 μ, w 2 5 μ) seems close to var *tenue* (Leuvin) W & G S West

CLOSTERIUM JUNCIDUM Ralfs — Pool Sta 148, Lookout Mt

CLOSTERIUM LIBELLULA Focke — L 203 μ, w 36 μ Wet moss Sta 130, Doctors Hill

CLOSTERIUM LIBELLULA near var INTERMEDIUM Roy & Biss (Pl XLV, Fig 18) — L 134-190 μ, w 26-28 μ Wet moss Sta B 6, St Johns

CLOSTERIUM MONILIFERUM (Bory) Ehrenb (Pl XLVI, Fig 15) — L 188-264 μ, w 30-44 μ Ditch, thickets, and seepy slopes Stas 129, Doctors Hill 102, 103, McIvers Cove, B 6, 7, 9, 20, St Johns, B 21, Whitbourne Strøm's f *minor* (1926) is close to the lower range of this material

CLOSTERIUM PARVULUM Naeg (Pl XLVI, Fig 4) — L 121-124 μ, w 9 5-12 8 μ Wet limestone rocks and peaty pools Stas 124, St John Bay, 140, Lookout Mt

CLOSTERIUM PRITCHARDIANUM Arch (Pl XLV, Fig 24) — L 530-554 μ, w 34-50 μ Ditch and wet moss Stas 101, McIvers Cove, B 20, Whitbourne

CLOSTERIUM PSEUDODIANAE Roy (Pl XLVI, Fig 5) — L 178-210 μ, w 13-15 μ Pools Stas 148, Lookout Mt, B 21, Whitbourne

CLOSTERIUM RALFSII De Bréb var IMMANE Cushm f — L 530-563 μ, w 72 84 μ, wall brown, finely striate Wet thicket Sta 103, McIvers Cove

These plants are close to the variety described by Cushman (1908), but relatively broad

CLOSTERIUM ROSTRATUM Ehrenb var BREVIROSTRATUM West (Pl XLVI, Fig 12) — L 315-374 μ, w 22-24 μ, w at cell apices 4 μ Ditches, pools, and wet moss Stas 103, McIvers Cove, B 6, 9, 20, St Johns, B 21, Whitbourne

CLOSTERIUM SETACEUM Ehrenb (Pl XLVI, Fig 11) — L 290–304 μ, w 7 5–9 5 μ Pools Stas 140, Lookout Mt, F 8, Grandys Brook, B 26, Whitbourne

CLOSTERIUM STRIGOSUM De Bréb (Pl XLVII, Fig 11) — L 233 256 μ, w 15–17 μ Ditches Sta 102, McIvers Cove

CLOSTERIUM STRIOLATUM Ehrenb L 135 280 μ, w 22–28 μ, w at apices 7–10 μ, membrane brown, about 16 striae across cell Wet limestone rocks and in wet moss Stas 122, Pointe Riche, B 6, St Johns

CLOSTERIUM SUBULATUM (Kg) De Bréb (Pl XLVI, Fig 6) — L 170 μ, w 7 5 μ, w at apices 2 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

CLOSTERIUM TOXON W West — Reported by Cushman (1907) from St Anthony

CLOSTERIUM TUMIDUM Johns, near f MINUS Strøm (Pl XLVI, Fig 1) — L 62–64 μ, w 5 7–7 0 μ Wet peaty slope Sta 129, Doctors Hill

CLOSTERIUM TUMIDUM var NYLANDICUM Gronbl, f **macrosporum,** f nov [1] (Pl XLV, Figs 21 22) – Cells of moderate size, slightly curved, ventral margin barely tumid, ends slender, depressed-rounded, chromatophore about four-ridged about four pyrenoids in each semicell, membrane smooth, colorless, gamete cells inclosing the zygospore, the wall of which is moderately thick and colorless, oval to truncate, and slightly produced at the angles L 150–165(-220) μ, w 13 15(19) μ zygospore l 58–63 μ, w 28 34 μ Seepy runnels Stas 136, Eddys Cove (type locality), B 6, St Johns

These plants were too small for *C strigosum*, too large for *C acutum*, and differed in other particulars The var *Nylandicum* of Gronblad (1921) seems to be a satisfactory allocation of the material, except for the size of the zygospore and the diameter of the vegetative cells, since the figures of the plants from these

[1] *Closterium tumidum* Johns var *Nylandicum* Grönbl f **macrosporum,** f nov — Cellulae modicae, paululo curvatae, margine ventrali vix tumidae apicibus angustis depresse rotundatis, chromatophoro ca 4-costato pyrenoidibus 4 in semicellulis alteris, membrana laevi, hyalina cellulis gameticis zygosporam modice et hyaline crassivallatam ovoideam vel truncatam angulis paululo productam includentibus Long 150–165(220) μ lat 13–15(-19) μ zygosp long 58–63 μ, lat 28–34 μ Newfoundland, in loco dicto Eddys Cove legit Bayard Long

two sources are almost identical in aspect Grönblad's measurements are l 100–200 μ, w 8–11 μ, zygospore l 30–40 μ, w 17–19 μ, so that zygospore dimensions form the only convincing basis for separation and induce the assignment of form status only to this material The larger plants with additional pyrenoids (Fig 22) came from the more southern station, had a somewhat different aspect, and lacked zygospores Cell diameter effectually rules out *C punctatum* Skuja (1928)

CLOSTERIUM VENUS Kg (Pl XLVI, Fig 2) —L 58–78 μ, w 9 5–10 μ Pools and wet moss Stas 119, Ingornechoix Bay, 122, Pointe Riche, F 9, Burgeo, B 6, 7, 9, St Johns, B 21, Whitbourne

CLOSTERIUM SP (Pl XLVI, Fig 14) —L 316–336 μ, w 52–59 μ, wall smooth and colorless In wet moss Sta B 20, St Johns

Distinguished from *C moniliferum* and *C eboracense* by the more numerous and scattered pyrenoids, this species will not fit into *C Ehrenbergii*, since it is more curved and has fewer pyrenoids

PLEUROTAENIUM Naegeli

PLEUROTAENIUM CORONATUM (De Bréb) Rabenh —Reported by Cushman (1907) from St Anthony

PLEUROTAENIUM CORONATUM var NODULOSUM (De Bréb) West (Pl XLVIII, Figs 5–6) —L 472–512 μ, w at apex 23–33 μ, w at base 40–65 μ, w at isth 33–40 μ Ditches and pools Stas 140, Lookout Mt, 102, 103, McIvers Cove

PLEUROTAENIUM EHRENBERGII (De Bréb) De Bary (Pl XLVIII, Fig 3) —L 340–404 μ, w 24–30 μ Pools Stas 116, St John Bay, 122, 135, Pointe Riche, 119, Ingornechoix Bay, 140, 146, Lookout Mt, 148, The Tableland, B 26, Whitbourne

PLEUROTAENIUM MINUTUM (Ralfs) Delp (Pl XLV, Fig 11) —L 160 μ, w 15 μ Pool Sta F 8, Grandys Brook.

PLEUROTAENIUM MINUTUM var ELONGATUM (W & G S West) Cedergren (Pl XLV, Fig 12) —L 310–320 μ, w 12–13 μ Pool Sta. 146, Lookout Mt

PLEUROTAENIUM MINUTUM var GRACILE Wille (Pl XLV, Fig 13) —L 137 μ, w 11 3 μ Pool Sta 146, Lookout Mt

Grönblad (1924) probably justly returns this species to Pleurotaenium, although many authors, with the Wests, keep it in

Penium De Toni (*Sylloge Algarum*, I 905 1889) accepts Pleurotaenium doubtfully, retaining Wille's varietal name without remark Grönblad (1924) reduces it to synonymy Since the varietal names serve at least a temporary purpose here they are retained The original figure of var *gracile* Wille (1881) does not show any taper to the cell, and the description lists material slightly smaller than that described above

PLEUROTAENIUM RECTUM Delp (Pl XLVII, Fig 8) — L 311–368 μ, w 18–21 μ Pool Sta F 8 (frequent), Grandys Brook

PLEUROTAENIUM RECTUM var RECTISSIMUM (W & G S West) Grönbl (Pl XLVII, Figs 9–10) — L 338–600 μ, w 24 4–28 μ Pools Stas 140, 146, Lookout Mt, F 8, Grandys Brook

The Wests (1904) give data which call for a large plant under this variety, but Grönblad (1924) admits smaller ones, with other characters in agreement

PLEUROTAENIUM TRABECULA (Ehrenb) Naeg, near f GRANULATUM G S West — L 422–447 μ, max w 65 μ, w at basal inflations 60 μ, w at apex 28–34 μ, isth 50 μ, wall clearly granulate Rills Sta 134, Pointe Riche

In shape this plant suggests f *clavatum*, but in size it exceeds both f *clavatum* and f *granulatum*

PLEUROTAENIUM TRIDENTULUM (Wolle) West (Pl XLVIII, Fig 2) — L 260 μ, w at base 13 μ, w at apex 8 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

PLEUROTAENIUM TRIDENTULUM var **Fernaldii**, var nov [8] (Pl XLVIII, Fig 4) — Cells long, capitulate, the end bearing six small teeth, shaft subcylindrical, inflated on each side of the isthmus, tapering with faintly curved contour to the infracapitular neck, surface of membrane beset with conical granules L 125–175 μ, w at base 7 5–7 7 μ, w at apex 4 5–5 6 μ Pool Sta F 8, Grandys Brook

This plant suggests *P tridentulum* var *capitatum*, but is smaller by half and has more numerous apical teeth, for which reasons it seems best to consider it varietally distinct

[8] *Pleurotaenium tridentulum* (Wolle) West var **Fernaldii**, var nov — Cellulae longae, capitulatae, apice breviter 6-dentatae, subcylindricae prope isthmum utrinque inflatae, gradatim laevissime ad constrictionem infracapitularem curvatae, membrana granulis conicis praedita. Long. 125–175 μ, lat. bas 7 5–7 7 μ, lat. pol 4 5–5 6 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

DOCIDIUM De Bréb

DOCIDIUM BACULUM De Bréb — Reported by Cushman (1907) from St Anthony

DOCIDIUM UNDULATUM Bail (Pl XLVIII, Fig 7) — L 202–220 μ, w 16 μ Pools Stas 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook

TRIPLOCERAS Bail [9]

TRIPLOCERAS GRACILE Bail (Pl XLVII, Fig 3 4) — L 338–422 μ, max w 30–42 μ Pools Stas 140, 146 (frequent), Lookout Mt

These plants in general were more slender than those figured by the Wests (1896), but were more sturdy than those of Smith (1924) or than f *kowdiensis* of Roll (1923)

TRIPLOCERAS GRACILE var **bispinatum,** var nov [10] (Pl XLVII, Fig 5) — Plants long, slender, semicells bifid at the expanded apex, the arms divergent, biaculeate, the spines side by side, the polar area granulate, shaft immediately below and between the terminal arms set with two small aculei, shaft generally cylindrical, armed with bosses in 8–10 whorls (approximately 8–12 to each whorl) each of which bears two superposed spines widely divergent in the longitudinal plane, or near the apex reduced to one outwardly directed spine, isthmus slightly contracted L 346–548 μ, w 22–28 μ Pond Sta 146, Lookout Mt

The paired spines on prominent swellings, as well as the form of the polar structures, differentiate this plant from *T gracile* In var *denticulatum* (Playf) G S West (1909) we have paired spines in whorls, but these are smaller, erect, and not elevated

[9] In spite of a decision to follow the classification of Printz (1927) for the Chlorophyceae, the writer prefers to retain Triploceras as a genus rather than to relegate it to sectional status

[10] *Triploceras gracile* Bail var **bispinatum,** var nov — Plantae longae angustae, semicellulis apice expanso bifidis, bracchiis divergentibus biaculeatis, aculeis binis, regione polari granulata, infra et inter bracchia aculeis 2 parvis praedita, ceterum fere cylindricae emergentionum 8–10 verticillis ornatae, verticillo ullo ex 8–12 emergentionibus longitudinaliter bicornutis vel biaculeatis constante, cornibus late divergentibus, emergentionibus quibusdam prope cellulae apicem plerumque simpliciter subuncinulate aculeatis, aculeo versus cellulae capitulum vergente, isthmo paulum contracto Long 346–548 μ, lat 22–28 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long

as pairs The apex is similar in form to those described by Nordstedt (1877, 1888) for his subspecies *bidentatum* and *aculeatum*, but the lateral whorled cornute spines are more prominent even than in his subspecies *bidentatum* var β *laticeps* or the f *intermedia* of that variety, the whorls less numerous than in subspecies *bidentatum*, and the plants are more slender throughout

TRIPLOCERAS VERTICILLATUM Bail — This species was represented in Newfoundland by two forms, quite distinct from each other, although growing intermixed Neither is just like the type figured and described (very inadequately) by Bailey (1851) The writer finds nothing in the Newfoundland sample to contraindicate description of these at least as varieties, but he infers from the literature that the species is considered quite variable, and so leaves the two forms under the original name

TRIPLOCERAS VERTICILLATUM (biradiate form) (Pl XLVII, Figs 1-2) — Plants large, stout, semicells biradiate at the concave apex, the arms very short or obsolete, at their apices rounded, biaculeate, the teeth side by side, upwardly divergent to erect, shaft below the apex naked for a very short space except for a pair of auriculate excrescences between the arms, sides of semicell bearing about 10 12 whorls, each of about twelve flattened, edentate, or distally acute thickened projections, isthmus slightly contracted L 401-472 μ, max w 42-46 μ Pool Sta 146, Lookout Mt

The original figure by Bailey (1851) shows a triradiate plant with apices ascending, and without a pronounced subpolar neck or excrescences between the arms, though a vague mark may suggest incrassation The genus is defined by Bailey as having triradiate tips, although, from the manner in which his figure of *T gracilis* is drawn, the specimen must have had two arms at the tip, with two subsidiary projections below at right angles

TRIPLOCERAS VERTICILLATUM (triradiate form) (Pl XLVII, Figs 6-7) — Plants large, stout, semicells triradiate (rarely biradiate) at the expanded apex, the arms flattened or slightly inflated above, slightly indented in the axial line, the arm apices rounded, biaculeate, the teeth side by side, transverse or upwardly divergent, shaft below the apex naked, this region usually terminated by one whorl of subobsolete projections, the shaft slightly broader near the isthmus, sloping gently toward the ends, set with 9-12

whorls of blunt to generally truncate and (near the isthmus) edentate projections, about 12–16 in each whorl, isthmus slightly contracted L 380–506 μ, max w 42 0–50 6 μ Pool Sta 146 (frequent), Lookout Mt

This plant, even when (very rarely) the apex has two arms, lacks the subapical auriculate excrescences, and has a more distinct contraction below the apex than the plant cited by Bailey (1851) Nordstedt (1888) described *T verticillatum* var *superbum* (Mask) Nordst with two primary and two lower secondary lobes, and the top not flattened, it has an even more contracted neck Cushman (1905) figures *T verticillatum* without auriculate excrescences, but the end is concave rather than flattened, and the cells are longer than these

COSMARIUM Corda

COSMARIUM ALPESTRE Roy & Biss (f) (Pl XLIX, Fig 5) — L 85 μ, w 64 μ Seepy rivulet Sta 136, Eddys Cove Smaller than that cited by the Wests (1908), and of slightly lesser relative width (1 1 30 instead of 1 1 19)

COSMARIUM AMOENUM De Bréb (Pl LIII, Fig 1) — L 52 μ, w 31 μ, th 24 μ Pools Stas 140, 141, Lookout Mt

COSMARIUM ANCEPS Lund (f) (Pl. XLIX, Fig 10) — L 28 μ, w 13 μ, isth 9 5 μ Pool Sta 135, Pointe Riche A similar form is recorded by Skuja (1930)

COSMARIUM ANCEPS f CRISPULUM Nordst (?) (Pl LI, Fig 34) — L 26 μ, w 17 μ, th 9 5 μ, isth 4 μ Pool Sta 140, Lookout Mt

COSMARIUM ANNULATUM (Naeg) De Bary var ELEGANS Nordst (Pl XLVIII, Fig 18) — L 56 μ, w 21 μ, isth 19 μ Pool Sta 119, Ingornechoix Bay

COSMARIUM BINUM Nordst (Pl LIII, Fig 20) — L 62 μ, w 48 μ Pool Sta 116, St John Bay

COSMARIUM BIOCULATUM De Bréb (f) (Pl LI, Fig 31) — L 28 μ, w 25 μ, th 11 3 μ, isth 4 3–4 5 μ Pools Stas 112, St John Bay, 119, Ingornechoix Bay, 140, Lookout Mt

Rather large, see the note under *C Portianum*, p 260.

COSMARIUM BOECKII Wille (Pl LIII, Fig 12) — L 38 μ, w 28–32 μ Pools Stas 122, Pointe Riche, 140, Lookout Mt

The figure and description of the type (Wille, 1881) call for

only four granules in the central area, instead of eight, as in the Newfoundland material

COSMARIUM BOTRYTIS Menegh (Pl LII, Fig 6) — L 72–111 μ, w 51–85 μ, isth 14 μ Pools Stas 116, St John Bay, 133, Doctors Hill, 122, 134, 135, Pointe Riche

COSMARIUM BOTRYTIS var GEMMIFERUM (De Bréb) Nordst (Pl LII, Fig 9) — L 72–79 μ, w 57–63 μ, th 33 μ, isth 13–17 μ Pools Stas 116, St John Bay, 140, Lookout Mt, 153, Petries

COSMARIUM BOTRYTIS var MEDIOLAEVE W West (Pl LII, Fig 7) — L 68–94 μ, w 54–77 μ, th 36 μ, isth 17 22 μ Pools Stas 124, St John Bay, 115, Ingornechoix Bay, 134, Pointe Riche, 137, Shoal Brook, 102, 103, McIvers Cove (common), B 20, St Johns

COSMARIUM BOTRYTIS var PAXILLOSPORUM W & G S West (Pl LII, Fig 1) — L 72–95 μ, w 58–61 μ, isth 13–15 μ Pools and rills Stas. 116, St John Bay, 136, Eddys Cove, 122, 135, Pointe Riche, 140, Lookout Mt

COSMARIUM BOTRYTIS var TUMIDUM Wolle (Pl LII, Fig 4) — L 76 μ, w 62 μ Pool Sta 122, Pointe Riche

COSMARIUM CAELATUM Ralfs (Pl. LIII, Fig 19) — L 43 μ, w 35 μ, isth 14 μ Pools Stas 129, Doctors Hill, 102, McIvers Cove, F 6, Great Barachois

COSMARIUM CAPENSE De Toni (f) (Pl L, Fig 17) — L 72 μ, w 50 μ, isth 25 μ Rills Sta 136, Eddys Cove

This plant suggests *C subcucumis* Schmidle, but the isthmus is too broad It is rather large for *C capense*

COSMARIUM CAPITULUM Roy & Biss (Pl LI, Fig 26) — L 16 21 μ, w 20–25 μ Pools Stas 122, Pointe Riche, 119, Ingornechoix Bay

COSMARIUM CAPITULUM var GROENLANDICUM Børg (Pl LI, Fig 25) — L 23 μ, w 19–24 μ, th 14 μ, isth 7 μ Pool Sta 122, Pointe Riche

COSMARIUM CONNATUM De Bréb (Pl XLIX, Fig 4) — L 88–94 μ, w 60–67 μ, isth 47–52 μ Pools Stas 122, 135, Pointe Riche, 119, Ingornecholx Bay, 140, Lookout Mt

Wall thick, finely punctulate between the obvious pores

COSMARIUM CONSPERSUM Ralfs var ROTUNDATUM Wittr — L 96 μ, w 75 μ, isth 26 μ Rills Sta 136, Eddys Cove

COSMARIUM CONTRACTUM Kirchn (Pl L, Fig 5 [large form]) —

L 31 36 μ, w 22-29 μ, isth 8 μ A large form of the same (?) L 51-52 μ, w 28-32 μ, th 25 μ, isth 4 μ Pools Stas 122, Pointe Riche, 119, Ingornechoix Bay, 140, 146, Lookout Mt, F 8, Grandys Brook

COSMARIUM CONTRACTUM var ELLIPSOIDEUM (Elfv) W & G S West (Pl L, Fig 1) — L 45-50 μ, w 34-38 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

COSMARIUM CONTRACTUM var JACOBSENII (Roy) W & G S West — Reported by Cushman (1907) from St Anthony

COSMARIUM CUCUMIS (Corda) Ralfs — Reported by Cushman (1907) from St Anthony

COSMARIUM CUCURBITA De Breb (Pl LI, Fig 6) — L 36-38 μ, w 21-22 μ, isth 15 μ Pools Stas 145 (frequent), 146, Lookout Mt, F 6, Great Barachois, F 8 (frequent), Grandys Brook

COSMARIUM CUCURBITINUM (Biss) Lütkem (Pl XLV, Fig 15) — L 60 μ, w 32 μ Pool Sta F 8, Grandys Brook

COSMARIUM CUCURBITINUM (f) (Pl XLV, Fig 14) — L 51 μ, w 15 μ Pool Sta 146, Lookout Mt

COSMARIUM CUCURBITINUM, near f MINUS West — Pools Stas 130, Doctors Hill, F 8, Grandys Brook

COSMARIUM CYMATOPLEURON Nordst (Pl LI, Fig 35) — L 75-110 μ, w 53-75 μ, isth 24 μ Rills Sta 134, Pointe Riche

COSMARIUM DECEDENS (Reinsch) Racib — L 52 μ, w 25 μ, isth 16 μ Sta 130, Doctors Hill

COSMARIUM DEPRESSUM (Naeg) Lund (Pl L, Fig 19) — L 37-54 μ, w 38-51 μ, th 21 μ, isth 8-11 5 μ Pools Stas 116, 124, St John Bay, 135, Pointe Riche, 119, Ingornechoix Bay, 148, The Tableland

COSMARIUM DIFFICILE Lütkem (f) (Pl LV, Figs 5-6) — Cells small, one half longer than broad, semicells somewhat rounded, the apex slightly retuse, the basal angles rounded, the lateral margins slightly concave and the upper angles broadly rounded to truncate, faces slightly thickened above the center, minute scrobiculations about the apex and in two curved rows across the cell face, inconspicuous to apparently obsolete, the remainder of the wall smooth to at times very faintly punctulate L 32-38 μ, w 21-24 μ, isth 4 5-5 6 μ Pools Stas 112, St John Bay, 122, 135, Pointe Riche, 119, Ingornechoix Bay

COSMARIUM EXCAVATUM Nordst var DUPLO-MAJUS Lund (Pl LII,

Fig 3) — L 47 μ, w 24 μ, isth 15 μ Pool Sta 140, Lookout Mt

COSMARIUM FORMULOSUM Hoff (approaching var *Nathorstii*) — L 42 44 μ, w 42 μ, th 23 μ, isth 11 5 μ Pool Sta F 9, Burgeo

COSMARIUM FORMULOSUM var NATHORSTII (Boldt) W & G S West (Pl LIII, Fig 26) — L 44 52 μ, w 42 47 μ isth 13-15 μ Ditch and pools Stas 103, McIvers Cove F 9, Burgeo, B 21, Whitbourne

COSMARIUM FURCATOSPERMUM W & G S West (f) (Pl LV, Fig 4) — L 26 μ, w 25 μ, isth 7 5 μ Wet moss at edge of pond Sta 130, Doctors Hill

COSMARIUM GALERITUM Nordst (Pl XLIX, Fig 2) — L 60 μ, w 50 μ, isth 15 μ Seepy slope Sta 129, Doctors Hill

This material was slightly large for the designated species, but quite too small for varieties of *C Lundellii*, which it most resembles Forms of *C Hammeri* without retuse sides were seen in the same sample, but the number of pyrenoids aided in separating them from the specimens attributed to *C galeritum*

COSMARIUM GAYANUM De Toni var EBORASCENSE G S West (Pl LII, Fig 10) — L 105–110 μ, w 51-65 μ Pools Stas 146, Lookout Mt , F 8, Grandys Brook

COSMARIUM GRANATUM De Bréb (Pl LI, Fig 1) — L 34–52 μ, w 23–28 μ, isth 9 5 μ Pools Stas 136, Eddys Cove, 135, Pointe Riche, 140, Lookout Mt , 148, The Tableland, F 9, Burgeo

COSMARIUM GRANATUM var ELONGATUM Nordst (Pl LI, Fig 14) — L 54 μ, w 27-29 μ, isth 13 μ Rills Sta 134, Pointe Riche

COSMARIUM HAMMERI Reinsch — Reported by Cushman (1907) from Bay of Islands

COSMARIUM HAMMERI var HOMALODERMUM W & G S West (Pl LI, Figs 32–33) — L 63–69 μ, w 43-52 μ, th 28 μ, isth 11 15 μ Pools and seepy slopes Stas 129 (frequent), Doctors Hill, F 6, Great Barachois

This form was seen in a state of arrested division (from Sta 129) similar to that discussed under *Cosmarium tetraophthalmum* var *pyramidatum*

COSMARIUM HOLMIENSE Lund (Pl LI, Fig 5) — L 45–48 μ, w

27–28 μ, th 20–21 μ, isth 14–15 μ Wet cliff Sta 124, St John Bay

COSMARIUM HOLMIENSE var INTEGRUM Lund (Pl LI, Figs 2–3) — L 43–65 μ, w 24–40 μ, isth 13–21 μ Cliffs, pools, and seepy runnels Stas 136, Eddys Cove, 124, St John Bay, 122, 134, 135 (frequent), Pointe Riche, 148, The Tableland

COSMARIUM HUMILE (Gay) Nordst var **lacustre,** var nov [11] (Pl LI, Fig 30) — Cells very small, about as long as broad, semicells subrectangular to trapeziform, the basal and upper angles obliquely truncate, the sides bi-indentate, the upper indentation deeper, apex about six-crenate, with a slight projection of the ridges, especially the submarginal ones, on to the lateral faces, isthmus linear, face of semicell usually with two low swellings above the basal angles, or these obsolete, and with strong costae, the lateral ones somewhat weaker than the central, vertical view inflated-oval, the top faintly ridged, the sides crenate because of the costae, walls thin except on the incrassate faces L 14–15 μ, w 15–16 μ, th 8 5 μ, isth 5 μ Pools Stas 112, 116, St John Bay, abundant (type locality)

These plants, in marginal contour and size, at once suggest *C humile,* perhaps with somewhat accentuated sculpturing However, the strong incrassate costae distinguish them from even the more elaborate known varieties Except where the cell contents are destroyed it is not easy to distinguish this variety, but it is quite distinctive when empty cells are seen

COSMARIUM HUMILE var STRIATUM (Boldt) Schmidle (Pl LI, Figs 27–29) — L 11–16 μ, w 10–16 μ, isth 4–4 5 μ Pools Stas 112, St John Bay, 122, Pointe Riche, B 21, 26, Whitbourne Seemingly reduced in surface features in some small examples, as in Figure 27

[11] *Cosmarium humile* (Gay) Nordst var **lacustre,** var nov — Cellulae minimae isodiametientes, semicellulis subrectangularibus vel trapeziformibus, angulis basalibus et superioribus obliquiter truncatis, lateribus 2 indentatis, indentatione superiore quam altero sensim altiore, apice ca. 6-crenato, costis (praecipue eis submarginalibus) paululo in facies laterales proiectis, isthmo lineari, semicellularum faciebus costatis plerumque leviter supra angulos basales protuberantibus, gibbis vel obviis vel interdum obsoletis, costis centralibus quam lateralibus validioribus, cellulis aspectu verticali ovatis, inflatis, summitate obscure costatis, lateribus de costarum causa crenatis, membrana faciebus incrassatis exceptis tenui Long. 14–15 μ, lat. 15–16 μ, crass. corp 8.5 μ, lat. isth 5 0 μ Newfoundland, in loco dicto St John Bay, legit Bayard Long.

COSMARIUM IMPRESSULUM Elfv (Pl XLVIII, Fig 12, Pl LV, Fig 11) — L 21–26 μ, w 14 18 μ, isth 4 μ Pools and rills Stas 135, Pointe Riche, 116, St John Bay, 136, Eddys Cove, B 26, Whitbourne The forms with short cells approach var *alpicola* as described by Schmidle (1896), but are smaller

COSMARIUM IMPRESSULUM Elfv (f ?) (Pl LI, Fig 4) — L 24 μ, w 15 μ, isth 4 μ Pool Sta 140, Lookout Mt

Narrow for this species, it is paralleled by a form figured by Fremy (1930)

COSMARIUM IMPRESSULUM f MINUS Turn — Reported by Cushman (1907) from Rose-au-Rue

COSMARIUM IMPRESSULUM f SUBORTHOGONUM (Racib) W & G S West (?) (Pl XLVIII, Fig 20) — Plants small, about one half longer than wide, semicells depressed-semicircular, usually eight-undulate, the polar two somewhat isolated or at times somewhat reduced, the sides three-undulate, sinus deep, closed, semicell faces somewhat inflated, with a prominent, centrally placed incrassate nodule L 23–25 μ, w 13 5–17 μ, th 6 5 μ, isth 4 5 μ Pools Stas 135, Pointe Riche, 119, Ingornechoix Bay

These plants resemble those described by Raciborski (1889) except that the semicells are more elevated, with the central nodule more circumscribed, and the cells rather smaller throughout

COSMARIUM IMPRESSULUM f **tholiforme**, f nov [12] (Pl XLVIII, Fig 19) — Plants smaller and thinner than in the species, the upper two pairs of undulations suppressed to give retuse, rounded cell ends L 19 μ, w 13 μ, isth 5 μ Pools. Sta 119, Ingornechoix Bay

COSMARIUM LAEVE Rabenh (Pl LI, Figs 8, 15) — L 24–43 μ, w 16–29 μ, isth 6–7 μ Wet cliffs and pools Stas 112, 116, 124, St John Bay, 136, Eddys Cove, 134, 135, Pointe Riche, 119, Ingornechoix Bay Ranging one fourth larger than the British plants (the Wests, 1908)

COSMARIUM LAEVE var SEPTENTRIONALE Wille (Pl LI, Figs 7 [f], 16, Pl LIV, Fig 17) — L 29–34 μ, w 19–21 μ, isth 8 0–8 5 μ Pools Stas 116, St John Bay, 136, Eddys Cove, 122, Pointe Riche The plant in Figure 7 resembles (in part) Johnson's

[12] *Cosmarium impressulum* Elfv f **tholiforme**, f nov — Plantae minores et tenuiores quam in f typica, undulationibus superioribus binis obsoletis, apicibus obscure retusis. Long 19 μ, lat 13 μ, lat. isth 5 μ Newfoundland, in loco dicto Ingornechoix Bay, legit Bayard Long

idea (1894) of *C impressulum* Its ratio of length to breadth, however, is nearer that of *C laeve septentrionale*

COSMARIUM LAGOENSE Nordst (Pl LIV, Fig 14) — L 42 μ, w 45–50 μ, th 30 μ Pool Sta 146, Lookout Mt

COSMARIUM LOGIENSE Biss (Pl LIII, Fig 21) — L 51–65 μ, w 44–55 μ, th 30 μ, isth 17–18 μ Seepy slope and pool Stas 129, Doctors Hill, 148, The Tableland

Cosmarium Longii, sp nov [13] (Pl LIV, Fig 8) — Cell moderately small, wider than long, semicells somewhat kidney-shaped, the apex depressed, the sides produced, straight or slightly concave, the base centrally inflated, apex gently curved, usually lightly incrassate, the basal angles rounded, sinus partly inflated, distally closed and with a linear apex, face of semicells with auriculiform verrucae midway above the sinus apex, and either two or three granules or a complex auriculiform verruca toward the basal angles, polar view long-oval, the ends rounded, the middle section inflated, incrassate, and bearing groups of projections near each end, further groups of incrassate projections between midsection and the ends L 26–32 μ, w 38–42 μ, th 18–19 μ, isth 5–6 μ Pool Sta 146, Lookout Mt

The species just described suggests *C navicularе* Borge (1918), but is not so slender and is more prominently ornamented

COSMARIUM LUNDELLII Delp var ELLIPTICUM W West f MINUS Strøm (Pl XLIX, Fig 3) — L 66 μ, w 50 μ, th 33 μ, isth 17 μ In a spring Sta 133, Doctors Hill

The Newfoundland specimens seem relatively a trifle longer than those studied by Strøm (1926)

COSMARIUM MALMEI Borge var **condensatum**, var nov [14] (Pl

[13] **Cosmarium Longii**, sp nov — Cellula modice parva, latior quam longior, semicellulis subreniformibus apice depressis vix incrassatis, lateribus productis, rectis vel supra paululo concavis, angulis basalibus rotundatis, sinu in media parte expanso, intus lineari, extus clauso, semicellularum faciebus cum verrucis compositis auriculiformibus singulis supra sinus apicem etiam cum 2–3 granulis vel verruca composita versus angulos basales, aspectu verticali elongate ovato in parte media inflato, apicibus rotundatis, incrassatis, et versus apices cum eminentiarum glomerationibus Long 26–32 μ lat 38–42 μ, crass corp 18–19 μ, lat isth 5–6 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long

[14] *Cosmarium Malmei* Borge var **condensatum**, var nov — Cellulae minutae, vix dimidio longiores quam latiores, subcylindricae, semicellulis depresse sphaericis, sinu non profundo, obtuse rotundato, margine minute crenulata, superficie cum granulis depressis in series horizontales et oblique decussatas ordinatis, ordinibus ca. 11, trans partem cellulae latiorem 15- vel 18-granulatis Long

XLVIII, Fig 11) — Cell small, slightly over one half longer than broad, subcylindrical, semicells depressed-spherical, the small sinus shallow, obtusely rounded margin slightly crenulate, surface with low granules in horizontal and obliquely decussate series, showing about eleven rows with 15 16 granules across the widest part of the cell L 36 μ, w 22 μ, th 22 μ, isth 17 μ Pool Sta F 8, Grandys Brook

This plant has a more abrupt and distinct sinus than does that described by Borge (1903), is smaller, and has smaller granules in closer rows

COSMARIUM MARGARITATUM (Lund) Roy & Biss (Pl LV Fig 2) — L 75 μ, w 57 66 μ, th 42 μ, isth 24 μ Pools Stas 134, 135, Pointe Riche, B 20, St Johns

COSMARIUM MARGARITATUM f MINUS (Boldt) W & G S West (Pl LII, Fig 5) — L 55 60 μ, w 55 56 μ, th 32 μ, isth 16 17 μ Pools Stas 135, Pointe Riche, B 26 (frequent), Whitbourne

These plants are rather wide for this form, as cited by the Wests (1911)

COSMARIUM MARGARITATUM var **ridibundum**, var nov [15] (Pl LII, Fig 8) — Cells moderately large, semicells somewhat kidney-shaped, with poles depressed, the basal angles abruptly rounded, the sinus closed without, somewhat expanded within, surface elevated into hollow conical projections which rise abruptly from the general surface in irregular obliquely decussate rows, somewhat reduced over the polar area, about 6 8 visible in the longitudinal axis, about 24–28 about the periphery of each semicell, the series nearest the isthmus forming a curved row, with the projection truncate or emarginate, notably deflexed and elongated toward the sinus, wall very thick, especially at the isthmus,

36 μ, lat 22 μ, crass corp 22 μ lat isth 17 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

[15] *Cosmarium margaritatum* (Lund) Roy & Biss var **ridibundum,** var nov — Cellulae mediocres, semicellulis subreniformibus, polis depressis, angulis basalibus abrupte rotundatis, sinu extus occluso, intus paulum expanso, superficie cum projectionibus vacuis conicis lineas irregulares oblique decussatas formantibus versus polos subobscuris ca 6–8 in axe longitudinali et 24–28 circum perimetrum visibilibus, iis lineae lunatae prope isthmum ad sinum deflexis et *elongatis dentiformibus* apice *truncatis* vel *emarginatis*, membrana praecipue ad isthmum crassissima inter proiectiones punctulata Long 85–88 μ lat 65 μ, lat isth 18 μ Newfoundland, in loco dicto Lookout Mt , legit Bayard Long

punctulations present in the rows between the projections L 85–88 μ, w 65 μ, isth 18 μ Pool Sta 140, Lookout Mt

This plant appears to belong to the *C margaritatum* group It has the hollow projections of var *subrotundata* W & G S West, but its shape is distinctly different The extraordinarily developed isthmial row, from its position and the refractive incrassation of the projections much more obvious in specimens than as figured, with the size and configuration, characterizes this species

COSMARIUM MENEGHINII De Bréb var NANUM Wille (?) (Pl XLVIII, Fig 15) — L 21 μ, w 15 μ, isth 4 5 μ Pool Sta 135, Pointe Riche

COSMARIUM MONILIFORME (Turp) Ralfs (Pl L, Fig 2) — L 24–39 μ, w 15–19 5 μ, isth 8 μ Pools Stas 122, Pointe Riche, 140, Lookout Mt

COSMARIUM MONOMAZUM Lund var POLYMAZUM Nordst (Pl LIV, Fig 4) — L 35–36 μ, w 37–40 μ Pool Sta 140, Lookout Mt

Donat (1931) accepts only one station in America, in New Jersey, for this plant

COSMARIUM NASUTUM Nordst (Pl LIII, Figs 9, 11) — L 34–37 μ, w 24–28 μ, isth 9–10 μ Seepy slope Sta 129, Doctors Hill

COSMARIUM NASUTUM, near var ASPERUM W & G S West (Pl LIII, Fig 10) — L 37 μ, w 28 μ, isth 10 μ Seepy slope Sta 129, Doctors Hill

Rather smaller than the Wests (1908) prescribe, and with only a single row of granules across the base of the semicell

COSMARIUM NORVEGICUM Strøm (Pl LIII, Fig 3, f ?, Fig 2) — L 24 μ, w 22 μ, isth 6 5 μ Pool Sta B 21, Whitbourne

The Norwegian mountain plant first reported by Strøm (1926) agrees excellently with this Sometimes the central group of granules seems absent (Pl LIII, Fig 2), but these plants (l 28 μ, w 27 μ, th 13 μ, isth 7 μ) otherwise conform to this species.

Cosmarium novae-terrae, sp nov [18] (Pl LV, Fig 10) — Cells moderately large, semicells subreniform, the polar area depressed

[18] Cosmarium novae-terrae, sp. nov — Cellulae modice grandes, semicellulis subreniformibus, ad aream polarem depressis vel subconcavis, lateribus et angulis basalibus rotundatis, sinum acutum exteriore parte expansum intus etiamque paulum expansum formantibus, aspectu polari late ovali, superficie

or slightly concave, the sides and basal angles rounded, so that the sinus is acute, outwardly dilated, with a slight inflation at the apex, polar view broadly oval, surface features consisting of blunt, solid subconical papillae over the margins of the cell, becoming reduced over the polar area, but not absent, and becoming sparser and lower over the sides until absent from the broad midfacial area, which is characterized by numerous shallow pits, small to moderate in size, often elongated longitudinally, irregularly, and somewhat sparsely scattered, laterally adjacent to, or slightly intermingled with, the projections, wall thick, between these major structures distinctly punctulate, pyrenoids two in each semicell L 77–84 μ, w 58–60 μ, th 44 μ isth 19–21 μ Pool Sta 146, Lookout Mt

This plant in structure suggests *C dentatum* Wolle, but in size, the basal angles, and the distribution of surface details, it is very different from that plant as described by the Wests (1896) *C superbum* from St Johns has superficial similarities, but is of a much more clearly defined pattern, and thinner

Cosmarium Nymannianum Grün (Pl XLVIII, Fig 13) — L 52–54 μ, w 38–42 μ, th. 24–26 μ, isth 7 5–9 5 μ Pools Stas F 6, Great Barachois, B 22, Whitbourne

Cosmarium ochtodes Nordst var (Pl LIII, Fig 22) — Cell of moderate size, about one third longer than broad, semicell subsemicircular, the apex depressed, the basal angles rounded, the sides slightly crenate, sinus linear, slightly open within, surface with flattened warts in series across the edges, about nine rows on each side of each semicell, from the face showing as about two series in curved rows near the apex and to four series toward the basal angles, the innermost row alone continuing over the upper region of the cell face in a much reduced form, membrane otherwise closely punctulate, the punctae in the polar areas forming blocks of transverse rows, but these are dispersed over the

papillis obtusis solidis in margine dispositis, iis in area polari reductis sed obviis in lateribus gradatim sparsioribus et plus applanatis hucusque ad aream mediefacialem excavatam, cavaturis numerosis minutis vel mediocribus saepe longitudinaliter elongatis, irregulariter subsparsis, lateraliter prope papillas dispositis vel interdum cum papillis fere intermixtis, membrana crassa distincte inter papillas et cavaturas punctulata, somatibus pyrenoideis utrinque 2 Long 77–84 μ, lat 58–60 μ, crass corp 44 μ, lat isth 19 21 μ Newfoundland, in loco dicto Lookout Mt ; legit Bayard Long

lateral faces L 65 μ, w 50 μ, th 28 μ, isth 12 μ Pool Sta 112, St John Bay

COSMARIUM OCHTODES Nordst var AMOEBUM W West (Pl LV, Fig 9) — L 95–113 μ, w 65–75 μ, th 48 μ, isth 19–22 μ Pool and wet thicket Stas 135, Pointe Riche, 103, McIvers Cove

Quite a little longer than the British examples (the Wests, 1911), but otherwise similar A small form (l 75 μ, w 60 μ, isth 18 μ) appeared in Sta 103, differing further in having the cell ends rounded or hardly truncate

COSMARIUM ORNATUM Ralfs (Pl LIV, Figs 7, 12) — L 28–38 μ, w 34–42 μ, th 22 μ, isth 9 5–11 μ Pools and ditch Stas 140, Lookout Mt, B 9, St Johns, B 26, Whitbourne

COSMARIUM ORTHOSTICHUM Lund (Pl LIII, Fig 5) — L 34 μ, w 30 μ, isth 9 μ Pool Sta 140, Lookout Mt

COSMARIUM PACHYDERMUM Lund (f) (Pl XLIX, Fig 6) — L 87–106 μ, w 71–81 μ, isth 29–30 μ Pools and seepy slopes Stas 129, Doctors Hill, 136, Eddys Cove, 135, Pointe Riche

Slightly broader (1 1 27) than the British plants (1 1 33), but see Grönblad (1924)

COSMARIUM PHASEOLUS De Bréb, near f MINUS Boldt (Pl L, Fig 18) — L 24 μ, w 22 μ, isth 4 5 μ Pools Stas 148, The Tableland, F 6, Great Barachois, F 8, Grandys Brook

COSMARIUM PLICATUM Reinsch (Pl L, Fig 12) — L 50–65 μ, w 30–38 μ, th 20–26 μ, isth 13–15 μ Pools Stas 116, St John Bay, 135, Pointe Riche, B 6, 20, St Johns, B 22, Whitbourne

COSMARIUM POKORNYANUM (Grün) W & G S West (Pl LI, Fig 18) — L 22–27 μ, w 14–19 μ, th 9 μ, isth 7 μ Pools and seeping rills Stas 122, 134, Pointe Riche

COSMARIUM PORTIANUM Arch (Pl LIII, Fig 4) — L 30–36 μ, w 22–28 μ, isth 9–10 μ Pools Stas 112, St John Bay, 122, 135, Pointe Riche, 140, 146, Lookout Mt

Sometimes nearly smooth, and then like *C biocutatum*

COSMARIUM PRAEGRANDE Lund (f) (Pl LV, Fig 3) — L 118–122 μ, w 69–75 μ, isth 22–23 μ, wall punctate between the solid papillae Pool Sta 135, Pointe Riche

Distinctly larger than the British plants (the Wests, 1911), and the wall slightly brownish

COSMARIUM PROTRACTUM (Naeg) De Bary (Pl LIV, Fig 16) —

L 39–40 μ, w 42–47 μ, th 25 μ, isth 10 μ Pools Stas 116 (frequent), St John Bay, F 8, Grandys Brook

Slightly wider than long, in contrast to the British examples (the Wests, 1908), which reverse the proportions

COSMARIUM PSEUDOCONNATUM Nordst (Pl LV, Fig 7) — L 48 μ, w 36 μ, isth 30 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

COSMARIUM PSEUDONITIDULUM Nordst – Reported by Cushman (1907) from Bay of Islands

COSMARIUM PSEUDONITIDULUM var VALIDUM W & G S West (Pl XLIX, Fig 7) — L 74–113 μ, w 63–77 μ, isth 22–28 μ Seepy slope Sta 129, Doctors Hill

COSMARIUM PSEUDOPROTUBERANS Kirchn (f ?) (Pl LI, Fig 24) — L 40 μ, w 35 μ, th 21 μ, isth 9 μ Wet moss Sta B 9, St Johns

The slightly flattened faces are different from the faces figured by Skuja (1928), and apical pores, which he figures, were not noted. It seems essentially identical with the plant reported by Johnson (1895) as typical

COSMARIUM PSEUDOPYRAMIDATUM Lund (Pl LI, Fig 23) — L 44 μ, w 30 μ, isth 7 5 μ Pools Stas F 6, Great Barachois, B 26, Whitbourne

COSMARIUM PSEUDOPYRAMIDATUM var **lentiferum**, var nov [17] (Pl L, Fig 7) — Cell of moderate size, about one half longer than broad, truncate-elliptical, semicell apices depressed, the sides curved, the basal angles rounded, sinus linear, wall moderately heavy, sparsely and finely punctulate, the faces markedly internally thickened in a refractive lenticular area about two fifths of the diameter of the semicell L 44 52 μ, w 28 36 μ, isth 8–13 μ Pools Stas 140, Lookout Mt (type), 148, The Tableland

Wille (1924) figures from the Antarctic a smaller form with slightly thickened sides, without distinctive name The var

[17] *Cosmarium pseudopyramidatum* Lund var **lentiferum**, var nov — Cellulae mediocres, dimidio longiores quam latiores truncatae ellipticae semicellulis apice depressis, lateribus curvatis, angulis basalibus rotundatis sinu lineari, membrana modice crassa sparse et minute punctulata, faciebus intus valde cum lente refractivo duas quintas semicellulae diametiente ornatus Long 44 52 μ, lat 28–36 μ, lat isth 8 13 μ Newfoundland, in loco dicto Lookout Mt, legit Bayard Long.

sublumidum of Raciborski (1889) is less thickened, has rounded poles and coarser punctulation

COSMARIUM PSEUDOTAXICHONDRUM Nordst var Foggii, var nov [18] (Pl LIV, Figs 9, 11) — Cell small, broader than long, semicells low, *truncate-triangular*, the length about two fifths of the width, apex slightly concave, incrassate, narrow, about two sevenths to one fourth of the width, the sides straight, the margin somewhat flexed above the basal angles, which are rounded, heavily incrassate, and beset with divergent rounded teeth, sinus nearly or quite closed midway of its length, and the outward inflation variable, to bring the teeth into contact or separate them by 4–5 μ, surface with two opposed dentiform granules on each side near the contraction of the isthmus and three widely spaced granules across the face about one third of the distance to the apex, the central ones larger than the lateral, occasionally a small granule within each basal angle, but this usually obsolete, polar view narrowly oval, the ends acute, the sides with three subconical granules, edge view of each semicell subcircular, slightly depressed at the pole, the isthmus relatively broad and widely open, the basal angles showing the opposed teeth and lateral granules, the cell faces showing the large sub-conical central granule, wall in face view rather thick except along the sloping sides L 24–26 μ, w 32–34 μ, th 13 μ, isth 5 5 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook (type)

This plant resembles somewhat the New Jersey form of *C*

[18] *Cosmarium pseudotaxichondrum* Nordst var **Foggii**, var nov — Cellula parva latior quam longior, semicellulis depressis truncati triangularibus, ad latitudinis duas quintas elongatis apice paululo concavo incrassato, angusto, ad latitudinis duas septimas vel quartam elongato, lateribus subplanis, margine supra angulos rotundatos basales paulo incurvata, valde incrassata et dentibus obtusis divergentibus praedita, sinu in media parte angustato obliterato, extus et intus modice expanso, extus nunc aperto, nunc clauso, superficie granulis duobus dentiformibus altero latere oppositis proxime ad isthmi constrictionem praedita, etiamque tribus granulis distantibus trans faciem dispositis ca. duas partes ex apice, medio quam lateralibus parvis majore, interdum cum granulo singulo in angulis basalibus sed eo plerumque obsoleto aspectu verticali anguste ovato, apicibus acutis, lateribus 3 granulis subconicis praeditis, aspectu semi cellularum aciali suborbiculari, vix ad polum depresso, isthmo modice lato et late aperto, angulis basalibus dentes oppositos et granulos laterales exhibientibus, cellularum faciebus granulum magnum centrale subconicum exhibentibus, membrana a facie cellulae visa subcrassiuscula lateribus obliquis exceptis Long 24–26 μ lat 32–34 μ, crass corp 13 μ, lat isth 5 5 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

pseudotaxichondrum reported by Wolle (1892), but is relatively shorter, with straighter sides, different number and orientation of the granules, and a distinctively different sinus

COSMARIUM PSEUDOTAXICHONDRUM var **septentrionale,** var nov [19] (Pl LIV, Fig 3) — Cells moderately small, wider than long, semicells angular, as if broadly triangular with all angles truncate, end flat or faintly concave, abruptly internally incrassate, upper lateral margins nearly straight, lower lateral margins abruptly truncate parallel with the axis (all intersections slightly rounded), sinus linear or very briefly inflated without, surface usually with two arcuate rows of conical incrassate granules, about six in the lower, four in the upper series, with the lateral members of the proximal series prolonged in opposition and deflected toward the sinus as rounded teeth, small casual granules often present, polar view narrowly oval, the semicell from beneath showing marginally about four groups of projections and underneath near each end revealing two dentiform granules L 22–25 μ, w 29–33 μ, th 11 5–13 μ, isth 3 8–4 5 μ Pool Sta F 8 (frequent), Grandys Brook

So far as the material in these collections is concerned, the writer is convinced of the distinctiveness of *C pseudotaxichondrum* vars *Foggii* and *septentrionale* and of *C Longii* The first two varieties grew intermixed, but whereas one was scarce, the other was generously represented, no suggestion of intergrades was detected In view of the variability of the species *pseudotaxichondrum* as currently interpreted, it seems well to associate these plants with it, but var *septentrionale* in particular may deserve segregation To consider such distinct forms identical with *C pseudotaxichondrum* would only introduce possible misconception of the distribution of the type

[19] *Cosmarium pseudotaxichondrum* Nordst var **septentrionale,** var nov — Cellulae modice parvae, latiores quam longiores, semicellulis angularibus, ut videtur, triangularibus cum angulis omnibus truncatis, apice plano vel leviter concavo, intus abrupte incrassato, marginibus superioribus lateralibus fere rectis, inferioribus axe parallelis abrupte truncatis, sinu lineari vel extus breviter expanso, *superficie plerumque cum granulis conicis incrassatis* in 2 series arcuatas ordinatis, in serie superiore 4, in serie inferiore ca 6, eorum extremis declinatis et pariter apicibus binis oppositis, aspectu verticali anguste ovato, semicellulis separatis e sinu visis cum 4 gregibus tuberculorum et versus apices alteros cum granulis 2 dentiformibus praeditis Long 22–25 μ, lat 29–33 μ, crass corp 11 5–13 μ, lat isth 3 8–4 5 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

COSMARIUM PUNCTULATUM De Bréb (var ?) (Pl LIII, Fig 18) — L 28 μ, w 27 μ, isth 7 5 μ Pool Sta 116, St John Bay

Granules of the central area large, depressed, not refractive, the ring with about four larger granules within

COSMARIUM PUNCTULATUM (var ?) (Pl L, Fig 6) — L 30–40 μ, w 25–30 μ Pool Sta 146, Lookout Mt

Suggesting var *rotundatum* Klebs and, even more, var *granulusculum* (Roy & Biss) W & G S West, but the sinus flares outwardly

COSMARIUM PUNCTULATUM var SUBPUNCTULATUM (Nordst) Børg f β (Pl LIII, Fig 14) — L 24–29 μ, w 23 25 μ, th 15 μ, isth 7 μ Pools Stas 119 (frequent), Ingornechoix Bay, F 9, Burgeo

COSMARIUM PYGMAEUM Arch (Pl LI, Fig 9) — L 9 5–11 5 μ, w 12–13 μ, isth 3 5–5 0 μ Pool Stas 145, Lookout Mt , B 26, Whitbourne

COSMARIUM PYRAMIDATUM De Bréb (Pl XLVIII, Fig 17, Pl L, Figs 15, 16 [f ?]) — L 65 100 μ, w 41–63 μ, isth 18–21 μ Pools Stas 134, 135, Pointe Riche, 119, Ingornechoix Bay, 140, 145, 146, Lookout Mt , 148, The Tableland, B 22 (with f), Whitbourne

The basal angles of part of the Whitbourne material were little rounded This form was seen (from B 22) in a state of arrested division of the type discussed under *Cosmarium tetraophthalmum pyramidatum*

COSMARIUM QUADRATUM Ralfs (Pl L, Fig 13) - L 59–65 μ, w 32–38 μ, isth 15- 21 μ Pools Stas 112, St John Bay, 136, Eddys Cove, 135, Pointe Riche

COSMARIUM QUADRIFARIUM Lund (Pl LV, Fig 1) — L 47 μ, w 38–40 μ, th 25 μ, isth 13–15 μ Pool Sta F 8, Grandys Brook

COSMARIUM QUASILLUS Lund (f) (Pl LIV, Fig 15) — L 82–92 μ, w 65–78 μ, th 45 μ, isth 21 μ Wet thicket Sta 103, McIvers Cove

COSMARIUM QUINARIUM Lund (Pl LIV, Figs 10, 13) — L 40–42 μ, w 32–38 μ, isth 10–11 μ Pools Stas 140, 146, Lookout Mt

Except for a slight difference in proportions, *C paulense* (Børg) Johns reported by Johnson (1895) very greatly resembles this plant

COSMARIUM RALFSII De Bréb var MONTANUM Racib (Pl XLIX, Fig 1) — L 113–128 μ, w 103–111 μ, isth 24 μ Ditches and pools Stas F 6, Great Barachois, B 28, Whitbourne

COSMARIUM RECTANGULARE Grün (Pl XLVIII, Fig 14) — L 37–44 μ, w 26–32 μ, isth 7 5–11 5 μ Pools Stas 135, Pointe Riche, 148, The Tableland

COSMARIUM RECTANGULARE var HEXAGONUM (Elfv) W & G S West (Pl LI, Fig 17) — L 28–29 μ, w 23 μ, isth 5–7 5 μ Pools Stas 122, 135, Pointe Riche, 124, St John Bay, B 21, Whitbourne

Cosmarium refringens, sp nov [20] (Pl L, Fig 10) — Cells small, about one third longer than broad, semicells transversely oval, the apex depressed, the upper lateral margins slightly flattened, the lower lateral margins and basal angles broadly rounded, sinus open, acute within, flaring outwardly wall moderately thick, incrassate across the poles and at the basal angles, with large and prominent sublenticular thickenings on the lateral faces, sparsely and finely punctulate I 38 μ, w 35 μ, th 22 μ, isth 8 μ Pool Sta F 8, Grandys Brook

COSMARIUM SCENEDESMUS var DORSITRUNCATUM Nordst (?) (Pl L, Fig 4) — L 20 μ, w 33 μ, th 11 5 μ, isth 5 μ

Station data lost Shorter than the type of the variety described by Nordstedt (1888) and with a much smaller isthmus

COSMARIUM SEXNOTATUM Gutw var TRISTRIATUM (Lütkem) Schmidle (Pl LIV, Figs 1 [f ?] 2) — L 19 21 μ, w 17 18 μ, isth 5 6 μ Pools Stas 140, Lookout Mt , F 8, Grandys Brook, B 26, St Johns

The St Johns plant differs principally in that the marginal crenations are bigranulate, suggesting *C subcostatum*

COSMARIUM SPHALEROSTICHUM Nordst (Pl LIII, Fig 15) — L 17 5–19 0 μ, w 15 5–16 μ, isth 4 5–5 0 μ Pool Sta 146, Lookout Mt

COSMARIUM SPECIOSUM Lund (Pl LIII, Fig 24) — L 48 57 μ, w 31–36 μ, isth 14 μ Pools Stas 116, 124, St John Bay, 136, Eddys Cove, 134, 135, Pointe Riche

COSMARIUM SPECIOSUM var BIFORME Nordst (Pl LIII, Fig 25) —

[20] **Cosmarium refringens,** sp nov Cellulae parvae, sparsim et minute punctatae ca. tertia parte longiores quam latiores, semicellulis transverse ovatis, apice depressis, marginibus lateralibus superioribus paulum planatis, inferioribus et angulis basalibus late rotundatis, sinu aperto, acuto, gradatim expanso membrana modice crassa, plus incrassata trans polos et ad angulos basales, faciebus lateralibus cum incrassationibus prominentibus sublenticularibus Long 38 μ, lat 35 μ, crass corp 22 μ, lat isth 8 μ Newfoundland in loco dicto Grandys Brook, legit J M Fogg, Jr

L 60–79 μ, w 38 51 μ, isth 20–28 μ Wet cliff and seepy rivulet Stas 136, Eddys Cove, 124, St John Bay

COSMARIUM SPECIOSUM var SIMPLEX Nordst (Pl LIII, Fig 23) — L 44 μ, w 31 μ, th 21 μ, isth 15 μ Pool Sta 112, St John Bay

COSMARIUM SPORTELLA De Bréb, near var SUBNUDUM W & G S West (Pl LIII, Fig 17) — L 52–56 μ, w 39–51 μ, isth 13–14 μ Ditches, pools, and wet thicket Stas 102, 103, McIvers Cove, B 6, 20, St Johns

COSMARIUM SUBCAPITULUM W West f **minus**, f nov [21] (Pl LI, Fig 11) — Plants closely similar in shape to the species, but differing in most dimensions, averaging a little more than half the size of the original form, and with the isthmus relatively broader L 8 5–11 μ, w 9 5–12 μ, th 3 5 μ, isth 3 5–4 5 μ Pool Sta B 26, Whitbourne

A slight modification of shape was seen in a very few individuals, which showed an additional retuse contour on each side of the semicell near the end, so that the semicell had eight angles instead of the usual six This may be a fixed difference requiring taxonomic segregation, but the sparseness of the evidence suggested the present disposal

COSMARIUM SUBCOSTATUM Nordst (Pl LV, Fig 12) — L 47 μ, w 43 μ, isth 11 μ Pool Sta 122, Pointe Riche

COSMARIUM SUBCRENATUM Hantzsch (Pl LIII, Fig 7) — L 25–29 μ, w 23–25 μ, isth 6 5–7 5 μ Pools Stas 116, St John Bay, 122, Pointe Riche

COSMARIUM SUBCRENATUM var **sublaeve**, var nov [22] (Pl XLVIII, Fig 16) — Cell small, about as long as broad, semicells truncate-semicircular, the ends flattened, the sides broadly curved, the basal angles shortly rounded, often apiculate, a single indentation on each side below the polar area, obscured by the apparent

[21] *Cosmarium subcapitulum* W West f **minus**, f nov — Plantae a forma typica differentes magnitudine fere dimidiata et isthmo relative latiores Long 8 5–11 μ, lat 9 5–12 μ, crass corp 3 5 μ, lat isth. 3 5–4 5 μ. Newfoundland, in loco dicto Whitbourne, legit Belle Burr

[22] *Cosmarium subcrenatum* Hantzsch var **sublaeve**, var nov — Cellulae parvae, isodiametientes, semicellulis truncato semiorbicularibus, apice planatis, sub apicem utrinque indentatione singula praeditis sed obscurata de causa indentationum minorum inter granula, lateribus curvatis, angulis basalibus breviter rotundatis, saepe apiculatis, semicellularum faciebus cum seriebus submarginalibus 2(–3) et una (interdum quarta valde imperfecta) marginali granulorum

dentations caused by the granules, face of semicell showing a marginal and 2 (–3) submarginal rows of small refractive spinuliform granules which in part of the inner series are paired, sometimes a few granules near the sinus suggest a fourth row, about five granules visible across the apex and five on the margin of each side, usually one very prominent granule on each side of the isthmus, wall between the granules sparsely and finely punctulate, polar view rounded-oblong, the sides inflated and incrassate, the central area becoming smooth, pyrenoid single in each semicell L 32–36 μ, w 29–32 μ, th 17 5–21 μ, isth 7–8 5 μ Pool Sta B 9 (frequent), Burgeo

COSMARIUM SUBCUCUMIS Schmidle (Pl L, Fig 11) – L 64–87 μ, w 43–47 μ, isth 14–19 μ Ditches, pools, and seepy slope Stas 129 (frequent), Doctors Hill, 102, McIvers Cove, B 20, St Johns, B 22, 27, Whitbourne

COSMARIUM SUBPROTUMIDUM Nordst (Pl LIII, Figs 6 [f ?], 8,13) — L 27–40 μ, w 24–38 μ, th 22–25 μ, isth 8 5–10 μ Pools Stas 116 (frequent), St John Bay, 122, Pointe Riche, B 21, Whitbourne

These plants range much larger than the British examples (the Wests, 1908), but seem essentially similar The plant shown in Figure 6 (from Sta 122) may belong here, but differs considerably, particularly in the central protuberance The subtruncate polar area is often very clearly defined

COSMARIUM SUBREINSCHII W West var OCELLATUM W & G S West (?) (Pl XLVIII, Fig 8) — L 32–33 μ, w 15–17 μ, th 12 μ, isth 4 5 μ Pools Sta F 6, Grandys Brook

The upper semicell face shows a scrobiculation surrounded by an internal thickening of the cell wall It is similar to *C venustum excavatum* (Eichl & Gutw) West, in the form figured by Grönblad (1921), except for size and the level of the scrobiculation His *C miedzyrzecense monomazum* is similar in size, but the lower semicell margins are not undulate, and the scrobiculation passes through an elevated papilla

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spinuliformum refractivorum intus pro parte geminatorum numero trans apicem 5 et in margine utrinque 5, etiam plerumque granulo solo versus isthmum, membrana inter granula sparse et minutissime punctulata, aspectu polari rotunde oblongo, lateribus inflatis incrassatis, area centrali laevi, somate pyrenoideo in semicellula unico Long. 32–36 μ, lat 29–32 μ, crass corp 17 5–21 μ, lat. isth. 7–8 5 μ Newfoundland in loco dicto Burgeo, legit J M Fogg, Jr

COSMARIUM SUBSPECIOSUM Nordst (f) (Pl LIII, Fig 16) — L 48 μ, w 30 μ, isth 18 μ Seepy rivulet Sta 136, Eddys Cove

Proportionately longer (1 1 6) than the British plants (the Wests, 1908), but otherwise very like them

COSMARIUM SUBTUMIDUM Nordst (Pl L, Fig 3) — L 42 μ, w 34 μ, isth 10 μ Pool Sta B 26, St Johns

COSMARIUM SUBUNDULATUM Wille (f) (Pl LIV, Fig 5) — L 60–63 μ, w 42 44 μ, th 32 μ, isth 14–17 μ Pools Stas 140, Lookout Mt, 148, The Tableland

The plants have a thick, faintly punctulate wall, and the contents show two pyrenoids in each semicell The proportions are slightly wider in some than the British examples (the Wests, 1905), and the ridges do not appear to be clearly undulate in the edge view of the cell No facial elevations appear, although two rows of low granules are shown on the original figures of Wille (1881) A plant reported by Gronblad (1924) is very similar to the Newfoundland specimens

Cosmarium superbum, sp nov [23] (Pl LII, Fig 2) — Cells moderately large, semicells semicircular, the polar area a little flattened, the basal angles rounded, sinus linear, slightly expanded within, polar view oval, the sides slightly inflated, surface areas differentiated into 2 regions, convex sides closely and shallowly pitted, the pits broad, about 10 pits lengthwise of the area and 13 across it, polar area smooth, the margin and outer portions of the sides otherwise beset with prominent widely spaced conical projections in irregular concentric rows, each projection hollow below, refractively thickened at the apex, about 2–3 rows visible from the side, 22 26 about the periphery of each semicell, wall, in general, moderately thin, incrassate at

[23] **Cosmarium superbum,** sp nov — Cellulae modice grandes semicellulis semiorbicularibus ad polum subplanatis, angulis basalibus rotundatis, sinu lineari, intus minute expanso, aspectu polari ovali lateribus inflatis, superficie in regiones tres divisa, prima ex lateribus convexis constituta dense sed leniter excavatis cavaturis numero longitudinaliter 10 trans aream 13, altera regione polari laevi, tertia marginali regione, cum partibus laterum exterioribus, tuberculis praedita conspicuis conicis subdistantibus irregulariter concentricis intus vacuis apice refractivis et incrassatis, ex cellulae latere visis 2 vel 3 series constituentibus, numero utrinque 22–26, membrana modice tenui solum ad isthmum et ad apices proiectionum tuberculiformum incrassata, in area excavata pallide brunnea, somatibus pyrenoideis utrinque 2 Long 75–78 μ, lat 63–64 μ, crass corp 34 μ, lat isth 21–25 μ Newfoundland, in loco dicto St Johns, legit Belle Burr

the isthmus and at the tips of the projections, pale brownish on the pitted areas, pyrenoids 2 to each semicell L 75–78 μ, w 63–64 μ, th 34 μ, isth 21–25 μ In wet moss Sta B 6, St Johns

This species suggests *C magnificum* Nordst (1888), but differs in its smaller size and in that the broader, closely placed pits on the facial areas are much more regular The papillae over the margins are different in being pointed, not truncate, as in *C magnificum* In polar view *C superbum* is less tumid than *C magnificum* Var *italicum* of Raciborski (1889) is not tumid, but the faces have even smaller pits than do those of the type

COSMARIUM TAXICHONDRUM Lund (f) (Pl LIV, Fig 6) — L 36–44 μ, w 33 46 μ, isth 9 μ Pools Stas 122, Pointe Riche, 140, Lookout Mt

The arrangement of the surface granules differs slightly from the British examples (the Wests, 1911), especially in the presence of two granules near the center of the semicell face

COSMARIUM TENUE Archer (Pl LI, Fig 10) — L 14 μ, w 15 5 μ, isth 4 μ Pool Sta 116, St John Bay

COSMARIUM TETRAOPHTHALMUM De Bréb (Pl LII, Fig 11) — L 119–120 μ, w 79–81 μ, th 56 μ, isth 21 28 μ Pools Stas 116, St John Bay, 119, Ingornechoix Bay, 122 (?), 135, Pointe Riche

COSMARIUM TETRAOPHTHALMUM var PYRAMIDATUM Strøm (Pl LII, Figs 12–13) — L 94–109 μ, w 71 84 μ, th 37 44 μ, isth 19–24 μ Seepy slope Sta 129, Doctors Hill, very common

There seemed to be a distinct range of variation in the form of the semicells, but within that shown by Strøm (1923), whose plants were slightly larger *C subochlodes* as reported by Schmidle (1895, Fig 26b) is also very similar, though smaller and relatively broader, but the Wests (1908) recognized as forms of *C cymatopleuron tyrolicum* Nordst, to which it is reduced in synonymy, much simpler plants, and therefore Strøm's name is tentatively adopted

A curious phenomenon appeared more frequently among the plants of this variety than among any other of the Newfoundland desmids Cells were found to have proceeded to the separation of the semicells at the isthmus preparatory to the development of daughter cell halves, but instead of forming two separate

protoplasts and wall units like those of the parent sections, they then organized a single structure, which persisted, connecting the old cell halves This usually had a somewhat squared form, and (in this variety) bore markings similar to those of the parent semicells, but differently placed to accord with the change in symmetry [24] *Cosmarium Hammeri homalodermum* showed this peculiarity also, as did *Cosmarium pyramidatum* In *Micrasterias decemdentata* there were found other excellent examples, which were especially interesting as exhibiting a more elaborate cell contour and the condition of the chromatophores, it appeared that four chromatophores were found in the central section, the complement of two semicells Unfortunately, the manner of preservation and mounting of the material rendered ineffective an attempt to discover what the behavior of the nucleus had been Probably it had failed to complete division Huber-Pestalozzi (1928) shows a similar condition in *Arthrodesmus Incus*, as does Schmidle (1896) in *C polonicum* Racib Wailes (1932) in *C subtumidum* and Huber-Pestalozzi (1927) in *C garrolense* Roy & Biss figure the process carried forward to the production of what is interpreted as a parthenospore

Cosmarium tinctum Ralfs (f) (Pl L, Fig 8) — L 19–21 μ, w 12–14 μ, th 8 5 μ, isth 10 μ Pool and wet moss Stas B 20, St Johns, B 21, Whitbourne

Distinctly larger than the British examples (the Wests, 1905) and with a very shallow sinus, but otherwise in agreement

Cosmarium trachypleurum Lund (f) — L 50 μ, w 47 μ, th 28 μ, isth 18 μ Pool Sta 146, Lookout Mt

This form showed the intramarginal structures as relatively large, flattened papillae rather than as conical elements, similar to those of the central protuberance, where they were more numerous and scattered than usual, with the interspersed pores irregularly distributed, and not as a ring

Cosmarium trilobulatum Reinsch var **majus**, var nov [25] (Pl XLVIII, Figs 9–10, Pl LI, Fig 13) — Cells small, semicell 4-sided, the apex depressed, the sides 3-undulate and sloping,

[24] Illustrations will accompany Part II of this study

[25] *Cosmarium trilobulatum* Reinsch var **majus**, var nov — Cellulae parvae, semicellulis 4-angulatis, apice depressis, lateribus 3-undulatis obliquis, angulis basalibus acute rotundatis, sinu clauso, faciebus granulum valde refractivum

the basal angles sharply rounded, the sinus closed, cell face bearing a strong refractive lobular granule on each side of the isthmus, but otherwise smooth, polar view broadly oval, somewhat produced in the median line, the sides a little thickened and slightly inflated L 40–43 μ, w 28–30 μ, th 18 μ, isth 5 5–7 5 μ Pools and rills Stas 136, Eddys Cove, 134, Pointe Riche (type locality)

This material was, perhaps, not always distinguished from *C venustum* These plants resemble *C trilobulatum* var *basicondrum* of Nordstedt (1887) and f *scrobiculata* of that variety described by Grönblad (1926), except in size and lack of scrobiculation, but are about one third larger, and respecting the type show a less pronounced polar lobe and more sloping sides

COSMARIUM TUDDALENSE Strøm (f) (Pl XLIX, Figs 8–9) — L 94–150 μ, w 65–101 μ, th 75 μ, isth 15 28 μ Pools and rills Stas 112, St John Bay, 134, Pointe Riche, 140, Lookout Mt

The two figures have forms markedly different from each other In relative proportions the longer type (1 1 53) is more elongate and the shorter (1 1 30) is more compressed than Strøm allows (1920) He does not describe the chromatophores, in the Newfoundland material there are two in each semicell, apparently sinuate-dissected, parietal, with numerous small pyrenoids (but see Grönblad, 1924) In details of shape many Newfoundland plants show a rather less subconical form and less rounded basal angles However, cells from both Stations 112 and 134 were noted with the subconical form marked in one semicell and the rounded form present in the other The subconical type, or semicell with lateral margins somewhat flattened, does not appear in either figure

COSMARIUM TUMIDUM Lund (f) (Pl L, Fig 9) — L 33 μ, w 26 μ, isth 8 μ Station data lost Wall punctulate

COSMARIUM UNDULATUM Corda, near var MINUTUM Wittr (Pl LI, Figs 19–[f] 20) — L 26–36 μ, w 20–24 μ, isth 5 5–7 5 μ Wet cliffs and rills Stas 136, Eddys Cove, intermediate in size, but

lobatum utrinque ferentibus ceterum laevibus, aspectu polari late ovali, axe paulum producto lateribus inconspicue incrassatis et vix inflatis Long 40–43 μ, lat 28–30 μ, crass corp 18 μ, lat isth 5.5–7 5 μ Newfoundland, in loco dicto Pointe Riche, legit Bayard Long

nearer to the variety than to the species, 124, St John Bay, 134, Pointe Riche, B 26 (frequent), Whitbourne

COSMARIUM UNDULATUM var WOLLEI W West (Pl LI, Fig 12) — L 24 32 μ, w 21 26 μ, isth 6 11 μ Stas 124, St John Bay, 136, Eddys Cove, 102, McIvers Cove, B 6, St Johns

COSMARIUM VENUSTUM (De Bréb) Archer (Pl LI, Fig 21 [f ?]) — L 29 μ, w 19 μ Pools and rills Stas 122, Pointe Riche, F 6, Great Barachois, F 8, Grandys Brook

Figure 21 represents a rather small form with strongly punctate walls, probably allied to this species

COSMARIUM VENUSTUM f MINUS Wille (Pl LI, Fig 22) — L 24 μ, w 18 μ, th 11 μ, isth 5 5 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

COSMARIUM VIRIDE (Corda) Josh (Pl L, Fig 14, Pl LV, Fig 8) — L 40-58 μ, w 24-27 μ, isth 18-19 μ In moss and on wet cliff Stas 124, St John Bay, B 6, 20, St Johns, B 21 (frequent), 24, Whitbourne

ARTHRODESMUS Ehrenb

ARTHRODESMUS BULNHEIMII Racib var SUBINCUS W & G S West (Pl LVI, Fig 10) — L of body 26-28 μ, l over spines 44-52 μ, w of body 24-26 μ, w over spines 48-52 μ, isth 4 5-6 μ Pool Sta 140, Lookout Mt

According to measurements given by Raciborski (1889) and the Wests (1911), this is too small for the species, although Smith (1924) admits plants even smaller than those from Newfoundland The Wests' variety is in closer agreement in shape, and but little smaller than the Newfoundland specimens

ARTHRODESMUS CONVERGENS Ehrenb (Pl LVI, Fig 11) — L 41 μ, w 23 μ, w over spines 65 μ Pools Stas 146, Lookout Mt, B 21, Whitbourne

ARTHRODESMUS IMPAR (Jacobs) Gronbl (Pl LVI, Fig 12) — Plant of moderate size, each semicell with four stout spines into the bases of which the cell cavity slightly extends, upper spines strongly divergent, polar area concave, lateral spines subparallel to generally divergent, contour between the upper and lateral spines depressed to concave, sinus open, tapered and rounded within, semicell sides therefore sloping to the isthmus, wall sparsely punctate

L of body 32–33 μ, l over spines 65–77 μ, w of body 36–38 μ, w over spines 65–79 μ, isth 11–13 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

These plants are perhaps a little smaller than those of Grönblad (1921), but since the present writer measured to the bottom of the depressed polar area this may be partly accounted for *A longispinus* Borge is rather similar, but the sinus is more acute, the apex less concave, and the spines are relatively longer See also *A octocornis* var *giganteus* Schmidle (1898)

ARTHRODESMUS INCUS (De Bréb) Hass (f) (Pl LVI, Fig 7) — L of body 21 μ, l over spines 47 μ, w of body 17 μ, w over spines 47 μ, isth 7 5 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

This plant is suggestive of var *validum* W & G S West, but is much smaller and has relatively shorter spines and a wider sinus

ARTHRODESMUS INCUS var EXTENSUS Anders (Pl LVI, Figs 3–5) — L of body 24–34 μ, w of body 17–22 μ, w over spines 41–65 μ, isth 7 5–8 5 Pools Stas 146, Lookout Mt, F 8, Grandys Brook

ARTHRODESMUS INCUS var INDENTATUS G S West (Pl LVI, Fig 9) — L of body 15–20 μ, l over spines 30–38 μ, w of body 11–15 μ, w over spines 34–38 μ Pools Stas 140, 146, Lookout Mt, F 8, Grandys Brook

ARTHRODESMUS INCUS var LONGISPINUS Eichl & Racib — Reported by Cushman (1907) from St Anthony

ARTHRODESMUS INCUS var RALFSII W & G S West — Reported by Cushman (1907) from St Anthony

ARTHRODESMUS OCTOCORNIS Ehrenb (Pl LVI, Fig 8) — L of body 19 21 μ, l over spines 33–40 μ, w of body 17 μ, w over spines 22–32 μ Pools Stas 130, Doctors Hill, 146, Lookout Mt, F 8, Grandys Brook, B 26, Whitbourne

ARTHRODESMUS QUADRIDENS Wood (Pl LIV, Fig 18) — Cells of moderate size, semicells depressed-semicircular with about six granules or spinous protuberances showing along the dorsal margin, isthmial angles acute or with a short spine, the sides just above the angles bearing a heavy upcurved spine, sinus closed, slightly inflated at the apex, wall heavy, cell surface from side view with a pair of heavy auricular thickenings contiguous across the isthmus, the face with three somewhat irregularly transverse rows of flattened granules, from the apex appearing

elliptical, acute, the ends terminated by the heavy spines, showing marginally the flattened granules of the lower lateral series, which give a crenate aspect, and with the upper series laterally placed within, the smaller granules or spines which interrupted the upper margin from side view appearing as central or sublateral granules nearer the upcurved spines L 34–35 μ, w of body 30 38 μ, w over spines 50–52 μ, th 22 μ, isth 10–13 μ Pool Sta 146, Lookout Mt

This quite inadequately known plant is one of the most interesting members of the Newfoundland flora The figures and descriptions of the New Hampshire plant by Wood (1869, 1873), and by Wolle (1884) are incomplete Wolle gives a width ("diameter") of 19 μ for this species, which even without the spines must be an error The heavy incrassate surface granules are not appropriate to Arthrodesmus, *Cosmarium horridum* Borge (1918) (= *Xanthidium ornatum* Borge [1903]) suggests a connection with that genus, Wolle offers an *A Rauii* from New Jersey, which also shows surface verrucae reported as remaining after spines have broken off (!), an open sinus, and more highly placed lateral spines If Wolle's measurement is in error (as it must be according to Wood's figures and his own), the size distinction between *A quadridens* and *A Rauii* is invalidated Lagerheim (1886) described an *A quadridens* var *β aequalis* of similar size from Massachusetts, supposed to differ in having a non-crenulate margin, but since this margin character is due to the flattened surface granules, which are clearly figured by Lagerheim, it is hard to see how his variety has any value

ARTHRODESMUS TRIANGULARIS Lagerh (f) (Pl LVI, Fig 6) — L 19 μ, w of body 19 μ, w over spines 42 μ Pool Sta 119, Ingornechoix Bay

This specimen appears to be rather small for the species

ARTHRODESMUS TRIANGULARIS var INFLATUS W & G S West (Pl LVI, Fig 2) — L 32 μ, w over spines 77 μ Pool Sta 140, Lookout Mt

ARTHRODESMUS TRIANGULARIS var SUBTRIANGULARIS (Borge) W & G S West (Pl LVI, Fig 1) — L of body 24 μ, l over spines 32 μ, w of body 21 μ, w over spines 56 μ Pools Stas 146, Lookout Mt , B 21, Whitbourne

The specimens are rather small for this variety

XANTHIDIUM Ehrb

XANTHIDIUM ANTILOPAEUM (De Bréb) Kg (Pl LVII, Fig 8) — L 56 μ, max w 70 μ, w of body 53 μ Pool Sta 119, Ingornechoix Bay

XANTHIDIUM ANTILOPAEUM var HEBRIDARUM W & G S West (Pl LVI, Fig 15) — Max l 70–84 μ, l of body 43 54 μ, max w 57–84 μ, w of body 42 57 μ, th 32 μ, isth 12 μ Pools Stas 116, St John Bay, 122, Pointe Riche, 119, Ingornechoix Bay, 146, Lookout Mt

XANTHIDIUM ANTILOPAEUM var MINNEAPOLIENSE Wolle — Reported by Cushman (1907) from St Anthony

XANTHIDIUM ANTILOPAEUM var POLYMAZUM Nordst (Pl LVII, Fig 11) — Max l 65 μ, l of body 50 μ, max w 65 μ, w 47 μ, isth 15 μ Pools Sta 148, The Tableland

XANTHIDIUM ARMATUM (De Bréb) Rabenh (Pl LVII, Fig 13) Max l 123–150 μ, l of body 102–130 μ, max w 88 100 μ, w of body 65–75 μ, isth 27 μ Pools Stas 146, Lookout Mt, F 8, Grandys Brook

XANTHIDIUM ARMATUM var CERVICORNE W & G S West (Pl LV, Fig 13) — Max l 165 μ, max w 126 μ Pools Stas F 6, Great Barachois, F 8, Grandys Brook

XANTHIDIUM ARMATUM var FISSUM Nordst (Pl LV, Fig 14) — Max l 158 μ, l of body 130 μ, max w 109 μ, w of body 75 μ, max th 86 μ, th of body 60 μ, isth 28 μ Pool Sta F 8, Grandys Brook

Cushman (1904) reports a form of *X armatum* (l of body 148 μ, w of body 93 μ) with a central 4-dentate protuberance that comes close to this variety, but is somewhat more rounded

XANTHIDIUM CRISTATUM De Bréb (Pl LVII, Fig 9) — Max l 65 μ, w of body 50 μ, max w 55 μ, w of body 40 μ Pool Sta 146, Lookout Mt

XANTHIDIUM CRISTATUM var UNCINATUM De Bréb (Pl LVII, Fig 10) — Max l 80 μ, l of body 60 μ, max w 65–70 μ, w of body 42–47 μ, isth 13 μ Stas 146, Lookout Mt B 21, Whitbourne

Xanthidium obsoletum, sp nov [26] (Pl LVII, Fig 12) — Cell

[26] **Xanthidium obsoletum,** sp nov — Cellula modice magna, semicellulis transverse ovatis vel reniformibus versus apicem paulum angustatis ad angulos superiores et suprabasales papillis depressis late separatis incrassatis praeditis

moderately large, semicells transversely oval, somewhat narrower toward the apex, the contour interrupted by widely separated low incrassate projections at the upper and suprabasal angles, and usually between, so that each semicell may show six vague dentations, polar area broad, depressed-rounded, basal angles sloping to the closed sinus, face of semicell with a subcircular arc of coarse scrobiculations more pronounced above, which is usually bisected by a row of 2-4 additional scrobiculations, and wall generally diffusely punctulate, polar view oval, truncate at the ends and laterally inflated where the scrobiculate wall is notably incrassate, edge view of semicells subcircular, somewhat extended and sloping toward the isthmus, cell wall moderately thick L 52-58 μ, w 52 μ, th 28-32 μ, isth 9 5 μ Pool Sta F 8, Grandys Brook

In spite of the absence of developed spines these plants, from details of shape and character of surface scrobiculations, seem surely to be Xanthidia The irregular prominences on the margins are not in the median plane, but are approximately alternately offset laterally The temptation to consider them unarmed specimens of X *antilopaeum*, or any other member of the known flora, is countered by the impossibility of matching the cell body characters among those listed from the station, although numerous individuals of X *obsoletum* were observed

Xanthidium pseudobengalicum Grönbl (Pl LVI, Fig 16) — Cell of moderate size, semicells transversely oval, somewhat narrowed toward the pole, and sloping toward the open acute sinus, upper and suprabasal angles with a heavy, slightly upcurved spine, or two secondary spines between the angles, spines attached approximately in the median plane, or bases only a little displaced, but tips usually distinctly laterally deflected, wall moderately heavy, punctate Max 1 86-94 μ, 1 of body 60 μ,

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etiamque inter angulos papillas uniseriatas obscuras obsoletas ferentibus, i e semicellulis obsolete in aspectu laterali 6-crenulatis, area polari lata depressis rotundatis, angulis basalibus oblique in sinum clausum transeuntibus, semicellulae faciebus arco suborbiculari scrobiculationum grossarum sursum conspicuorum ornatis, plerumque a serie 2-4 scrobiculationum aliarum etiam intersecto, aspectu polari ovato, apicibus truncato, lateraliter inflato, ad regionem scrobiculatam membrana incrassata, semicellulis aspectu aciali suborbicularibus subextensis gradatim in isthmum obliquatis, membrana modice crassa. Long 52-58 μ lat 52 μ, crass corp 28-32 μ, lat isth. 9 5 μ Newfoundland, in loco dicto Grandys Brook, legit J M Fogg, Jr

max w 96–103 μ, w of body 48–53 μ, isth 15 μ Pool Sta 146, Lookout Mt

See *X bengalicum* in Cushman (1905), *X hastiferum Johnsoni* in the Wests (1898), and *X antilopaeum javanicum* in Johnson (1894–95), as they are cited by Gronblad (1921) *X subhastiferum Toweri* (Cushman) Smith (1921) is similar, but much smaller

XANTHIDIUM TORREYI Wolle (Pl LVI, Figs 13 14) — Cells of moderate size, semicells irregularly rectangular, the upper angles bearing heavy, erect, or somewhat divergent spines, sides with upwardly divergent heavy spines placed about midway to the isthmus, basal angles obtuse to rounded-rectangular, sloping slightly toward the closed sinus or rarely bearing a relatively small reflexed spine, margins between the spines concave, or the pole somewhat flattened, polar view narrowly oval, somewhat produced at the margins and inflated at the sides, where the wall is moderately thickened, the spines deflected laterally from their attachments near the median plane, edge view of cell showing semicells rounded, or somewhat elongated in the plane of the spines, which are laterally deflected, sinus open, acute, wall moderately heavy, finely punctate, bases of spines somewhat excavate Max l 63 71 μ, l of body 32 34 μ, max w 54–67 μ, w of body 28–35 μ Pools Stas 146, Lookout Mt, F 6, Great Barachois, F 8, Grandys Brook

This plant agrees well with Wolle's New Jersey plant (1887), except in a slightly lesser length over the spines, a greater divergence in the lateral spines, and in that the basal angles are more abrupt, so that the sinus is more sharply closed without It seems hardly worth while to make a varietal segregation Schmidle (1898) described an *Arthrodesmus octocornis giganteus* from Pite Lappmark which is remarkably like the present material, although the upper spines are more divergent, the lower more parallel than in the Newfoundland material, there is no significant difference in size The irregular placement and deflection of the spines encourage retention of this material in Xanthidium, and Wolle's name having priority is in consequence accepted for the Newfoundland specimens

The genus Xanthidium contributed little to the general character of these Newfoundland samples The collection from

Station 146 alone had any considerable variety, and even here Xanthidia were not conspicuous in numbers in the rich assortment of desmids represented Consequently, the presence of three interesting types, *X obsoletum*, *X pseudo-bengalicum*, and *X Torreyi*, is particularly surprising, since only six species are noted in the flora

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EXPLANATION OF PLATES XLV–LVII

In general throughout these plates nuclei have been stippled solid, chromatophore and pyrenoid outlines have been indicated by dotted lines but since these are made from preserved material they are not to be considered critically illustrative of the living cell, broad lenticular membrane thickenings have been indicated by concentric dotted lines punctulation and granulation have been indicated by dots or by circles of appropriate size on part of the cell surface but if very delicate have been omitted Drawings of the same species if adjacent have been connected by a dotted line and if separated on the plate generally have been indicated by a letter attached to the figure number All figures are original, executed by the author from the Newfoundland material and reduced by about three fifths in reproduction

PLATE XLV

Roya

1 *R obtusa* var *montana* (?) two cells, × 470
(See also Plate XLVI)

Netrium

2 *N oblongum* var *cylindricum*, × 470
3-4 *N Digitus*, two cells × 340, 565

Cylindrocystis

5 *C Brebissonii* var *minor*, two cells, × 470
6-7 *C Brebissonii*, three cells, × 470
8 *C diplospora* × 470
9 *C americana*, × 470
10 *C crassa*, × 470

Pleurotaenium

11 *P minutum*, × 340
12 *P minutum* var *elongatum*, × 340
13 *P minutum* var *gracile*, × 470
(See also Plates XLVII-XLVIII)

Cosmarium

14 *C Cucurbitinum* (f ?), × 725
15 *C Cucurbitinum*, × 565
(See also Plates XLVIII-LV)

Penium

16 *P cruciferum*, three cells, × 470
17 *P polymorphum*, × 470
(See also Plate XLVII)

Closterium

18 *C Libellula* var *intermedium*, × 340
19 *C didymotocum*, three cells, × 225, two apices, × 725
20 *C acerosum*, two cells, × 135, apex, × 725
21-22 *C tumidum* var *Nylandicum* f *macrosporum*, conjugating cells with zygospore (above), × 385, cell, × 340, apex, × 725, cell, × 385
23 *C acerosum* var *elongatum*, × 135
24 *C Pritchardianum*, two cells, × 135, 150, with apex, × 725
(See also Plates XLVI-XLVIII)

Spirotaenia

25 *S. condensata*, × 340

PLATE XIV

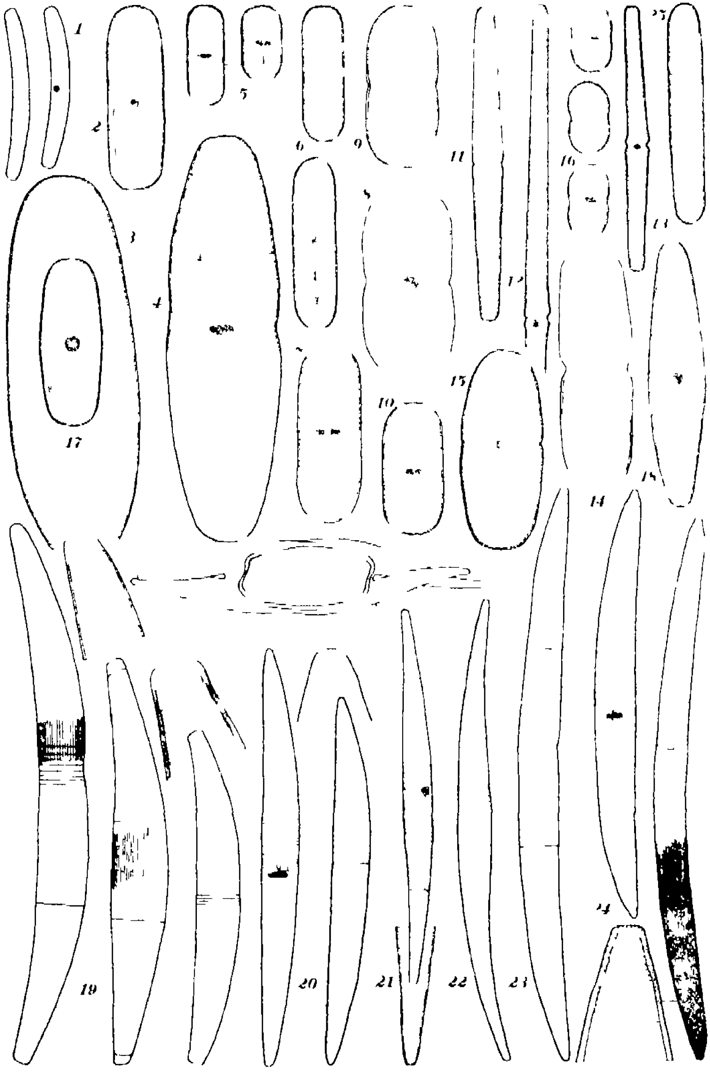


PLATE XLVI

Closterium

1. *C. tumidum* f. *minus*, three cells. × 470
2. *C. Venus*, two cells. × 125, 630
3. *C. Dianae* var., × 1250; apex × 725
4. *C. parvulum*. × 470
5. *C. pseudodianae*. × 340; apex × 725
6. *C. subulatum*. × 340
7. *C. gracile*, × 340
8. *C. Cornu*. × 565
9. *C. abruptum*, two cells. × 335
10. *C. Archerianum* (?), × 340; apex × 725
11. *C. setaceum*, two cells. × 340
12. *C. rostratum* var. *brevirostratum*, × 225; portion of surface one half the distance toward end, and apex × 725
13. *C. chorascense*. × 300
14. *C.* sp.?, two cells. × 225, apex × 725
15. *C. moniliferum*, two cells. × 290, 225; apex × 725
16. *C. gracile* var. *tenue* (?). × 340

(See also Plates XLV, XLVII, XLVIII.)

Roya

17. *R. obtusa* var. *montana* (?). × 90, apex × 815

(See also Plate XLV.)

PLATE XLVI

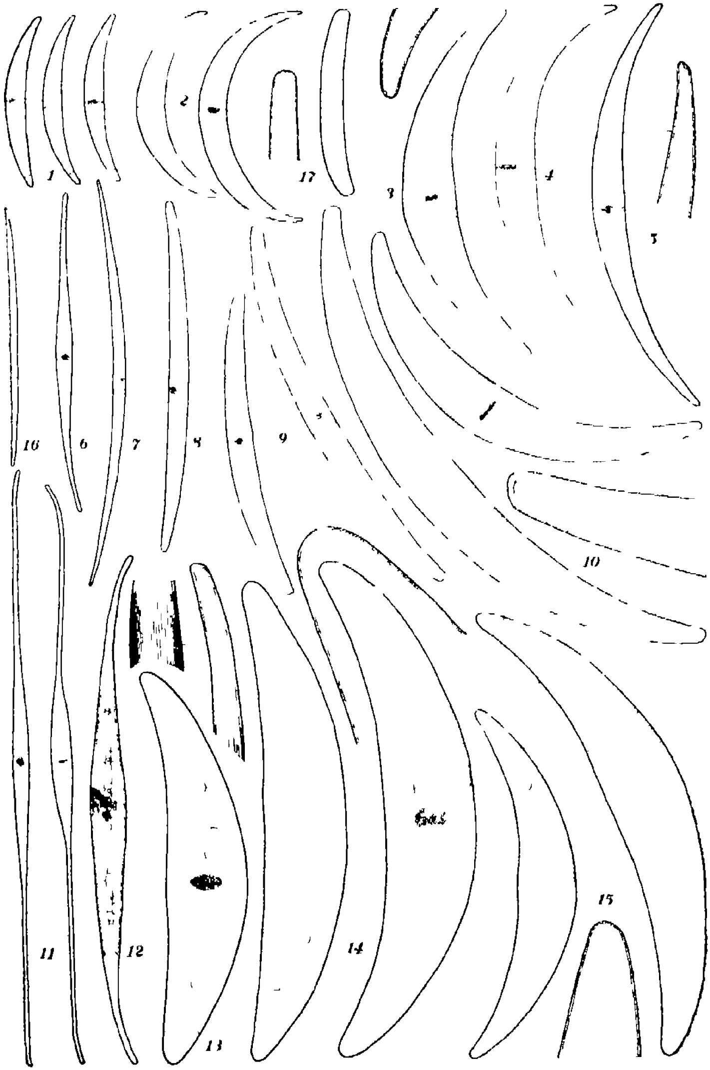


PLATE XLVII

Triploceras

1, 2. *T. verticillatum*, cell × 225; two views of cell apex at right angles × 340.

3, 4. *T. gracile*, cell × 225; cell apex and midsection × 340.

5. *T. gracile* var. *bispinatum*, cell × 225; midsection and two views of cell apex at right angles × 565.

6, 7. *T. verticillatum*, triradiate form × 225; apex × 340.

Pleurotaenium

8. *P. rectum* × 340.

9, 10. *P. rectum* var. *rectissimum*, two cells × 225.

(See also Plates XLV, XLVIII.)

Closterium

11. *C. strigosum*, two cells × 300.

(See also Plates XLV, XLVI, XLVIII.)

Penium

12. *P. spirostriolatum* × 300; apex × 470.

(See also Plate XLV.)

Gonatozygon

13. *G. Kinahani* var. *majus* × 135; apex × 340.

14. *G. aculeatum*, portion of filament × 340.

Hyalotheca[27]

15. *H. sp.?*, portion of filament × 565; cell × 725.

16. *H. dissiliens*, portion of filament × 585.

17. *H. mucosa*, portion of filament × 565.

[27] Discussion of these species, and illustrations of additional species, will appear in Part II of this study.

PLATE XLVII

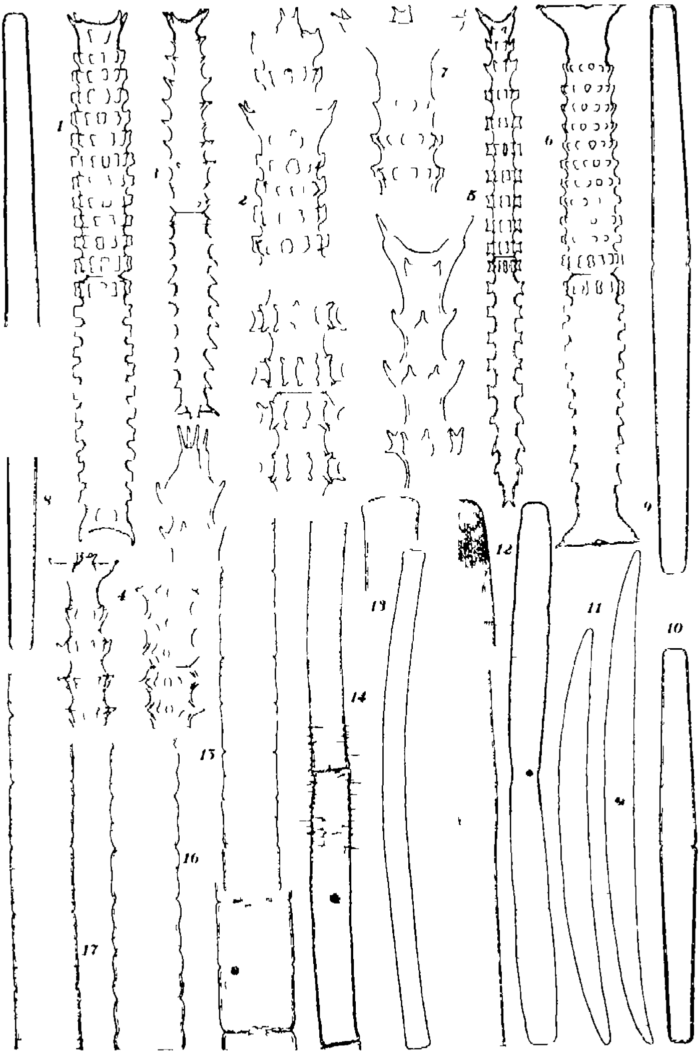


PLATE XLVIII

Closterium

1. *C. costatum* var. *Westii* × 225; apex × 725.

(See also Plates XLV–XLVII.)

Pleurotaenium

2. *P. tridentulum* × 340; apices × 725.
3. *P. Ehrenbergii*, portion of cell × 340.
4. *P. tridentulum* var. *Fernaldii*, two cells × 565.

5–6. *P. coronatum* var. *nodulosum*, portion of cell × 135; apex × 340; portion of cell × 300.

(See also Plates XLV–XLVII.)

Docidium

7. *D. undulatum* × 340.

Cosmarium

8. *C. subreinschii* var. *ocellatum* × 850.

9–10. *C. trilobulatum* var. *majus*, face view of two cells; top view × 725.

11. *C. Malmei* var. *condensatum* × 725.
12. *C. impressulum*, one cell face and portion of another × 850.
13. *C. Nymannianum*, face, edge and top views × 565.
14. *C. rectangulare* × 850.
15. *C. Meneghinii* var. *nanum* (?) × 850.
16. *C. subcrenatum* var. *sublaeve*, face and top views × 725.
17. *C. pyramidatum* × 585.
18. *C. annulatum* var. *elegans* × 725.
19. *C. impressulum* f. *tholiforme*, face and edge views × 850.
20. *C. impressulum* f. *suborthogonum* (?), face view of two cells × 850.

(See also Plates XLV, XLIX, LV.)

PLATE XLVIII

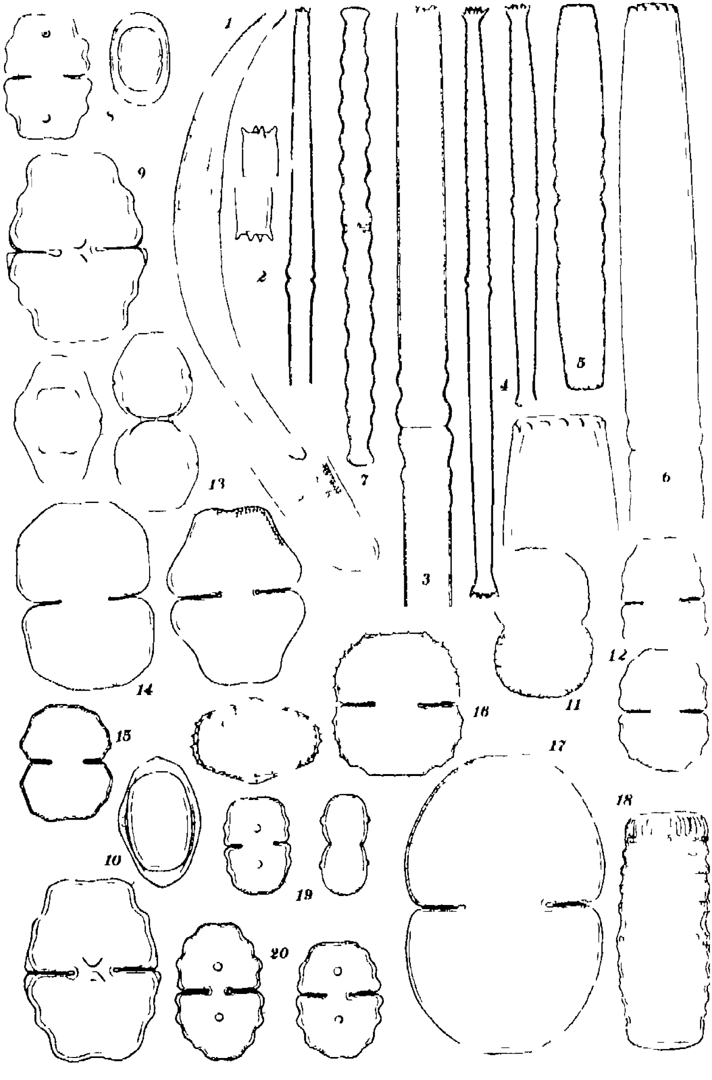


PLATE XLIX

Cosmarium

1. C. *Ralfsii* var. *montana* × 450
2. C. *galeritum* × 470
3. C. *Lundellii* var. *ellipticum* f. *minus*, face, edge and top views × 470
4. C. *connatum* × 565
5. C. *alpestre* × 565
6. C. *pachydermum* × 470
7. C. *pseudonitidulum* var. *validum* × 470

8, 9. C. *tuddalense*, two face views and edge view × 470

10. C. *anceps* × 850

(See also Plates XLV, XLVIII, L, LV.)

PLATE XLIX

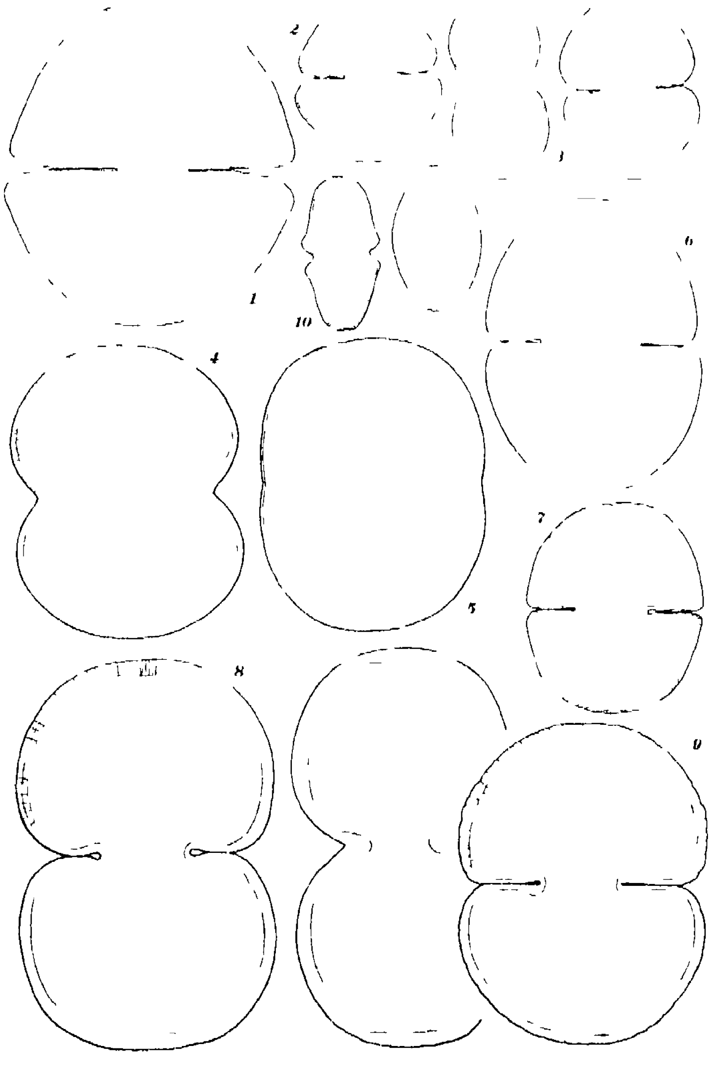


PLATE I

Cosmarium

1 C contractum var ellipsoideum × 725

2 C moniliforme top and side views × 725

3 C subtumidum × 725

4 C Scenedesmus var dorsitruncatum (?) × 725

5 C contractum (large form) face and edge views × 725

6 C punctulatum (var ?) × 725

7 C pseudopyramidatum var lentiferum × 725

8 C tinctum two cells × 725

9 C tumidum f × 850

10 C refringens face and edge views × 725

11 C subcucumis × 565

12 C plicatum face and edge views × 565

13 C quadratum × 565

14 C viride × 725

15 C pyramidatum × 725

16 C pyramidatum (f ?), × 565

17 C capense f × 565

18 C Phaseolus f minus, × 850

19 C depressum × 685

(See also Plates XLV XLIX LIV)

PLATE I

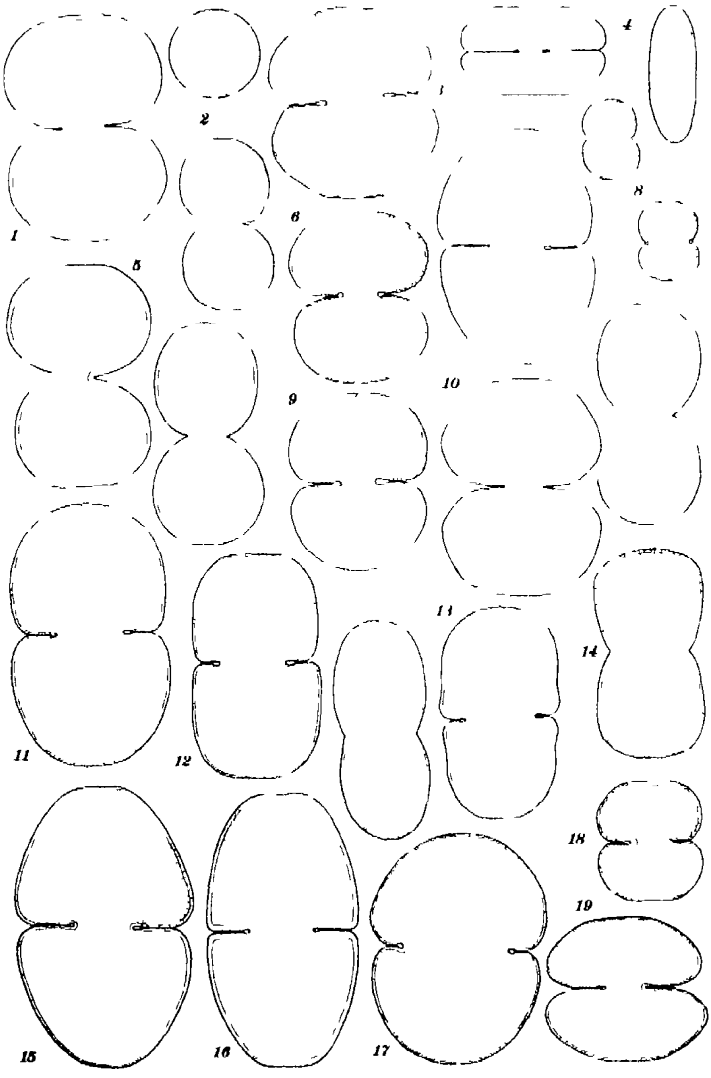


PLATE LI

Cosmarium

1. *C. granatum* × 850
2, 3. *C. holmiense* var. *integrum*, two cells × 725
4. *C. impressulum* × 850
5. *C. holmiense* × 725
6. *C. Cucurbita* × 725
7. *C. laeve* var. *septentrionale* f. × 725
8. *C. laeve* × 725
9. *C. pygmaeum*, three cells × 725
10. *C. tenue* × 725
11. *C. subcapitulum* f. *minus*, three cells, also edge and top views × 850
12. *C. undulatum* var. *Wollei* × 725
13. *C. trilobulatum* var. *majus* × 725
14. *C. granatum* var. *elongatum* × 725
15. *C. laeve* × 725
16. *C. laeve* var. *septentrionale* × 725
17. *C. rectangulare* var. *hexagonum* × 725
18. *C. Pokornyanum*, face and edge views × 725
19. *C. undulatum* var. *minutum* × 285
20. *C. undulatum* var. *minutum* f. × 285
21. *C. venustum* f. × 725
22. *C. venustum* f. *minus*, face and edge views × 725
23. *C. pseudopyramidatum* × 725
24. *C. pseudoprotuberans* f., face and top views × 725
25. *C. capitulum* var. *groenlandicum*, top and side views × 725
26. *C. capitulum* × 725
27–29. *C. humile* var. *striatum*, three cells × 850, 725
30. *C. humile* var. *lacustre*, two cells and top view × 725
31. *C. bioculatum* f. × 725
32, 33. *C. Hammeri* var. *homalodermum*, two cells × 565
34. *C. anceps* f. *crispulum* (?), face and edge views × 850
35. *C. cymatopleuron* × 470

(See also Plates XLV, XLVIII, L, LII, LV.)

PLATE II

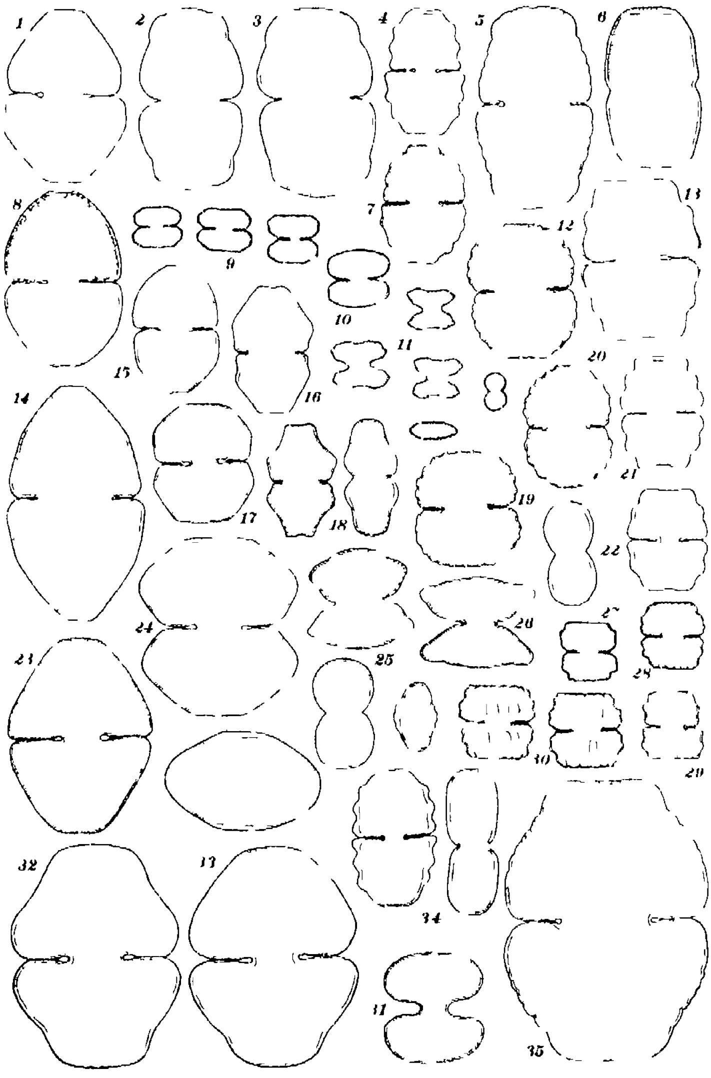


PLATE LII

Cosmarium

1. C. *Botrytis* var. *paxillosporum* × 565
2. C. *superbum*, face and top views × 565
3. C. *excavatum* var. *duplo-majus* × 725
4. C. *Botrytis* var. *tumidum* × 565
5. C. *margaritatum* f. *minus* × 565
6. C. *Botrytis* × 565
7. C. *Botrytis* var. *mediolaeve* × 565
8. C. *margaritatum* var. *ridibundum*, × 565
9. C. *Botrytis* var. *gemmiferum* × 565
10. C. *Cayanum* var. *eboracense* × 565
11. C. *tetraophthalmum* × 470

12–13. C. *tetraophthalmum* var. *pyramidatum*, cell, semicell and top views × 565

(See also Plates XLV, XLVIII, LI, LIII, LV.)

PLATE LII

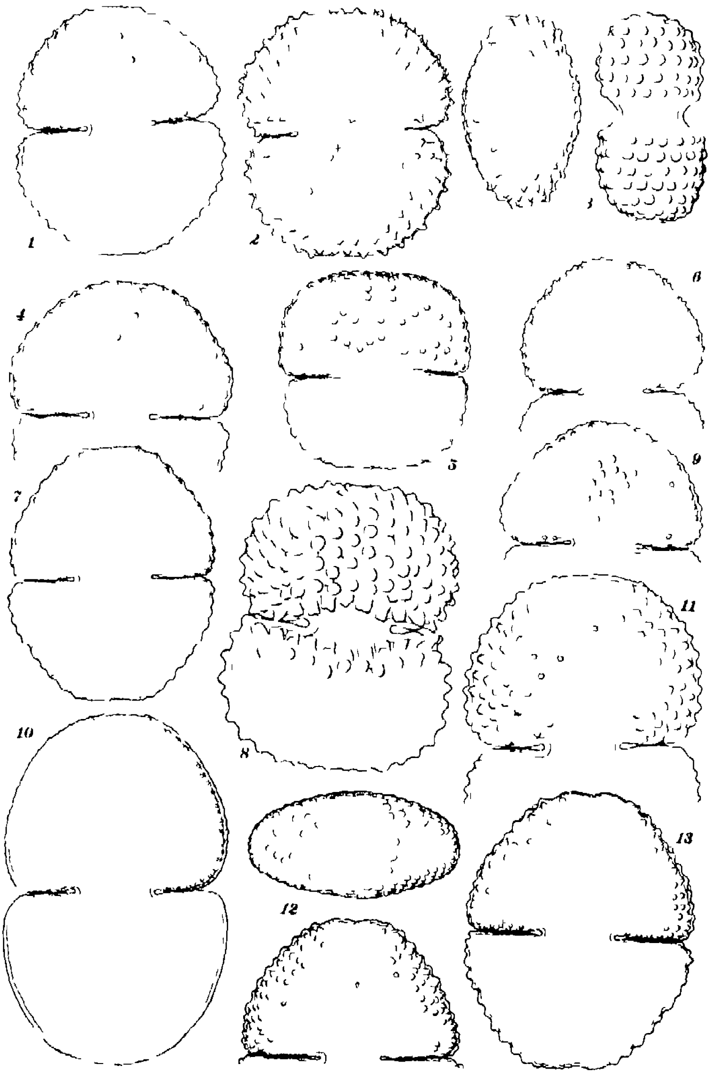


PLATE LIII

Cosmarium

1. C. *amoenum* × 725
2. C. *norvegicum* f. × 725
3. C. *norvegicum* × 725
4. C. *Portianum* × 725
5. C. *orthostichum* × 725
6. C. *subprotumidum* f. face and base of semicell × 630
7. C. *subcrenatum* × 725
8. C. *subprotumidum* × 630

9, 11. C. *nasutum* two cells × 725

10. C. *nasutum* var. *asperum* f. × 725
12. C. *Boeckii*, × 725
13. C. *subprotumidum* face, top and edge views × 630
14. C. *punctulatum* var. *subpunctulatum* face, top and edge views ×
15. C. *sphalerostichum* two cells × 725
16. C. *subspeciosum* f. × 630
17. C. *Sportella* var. *subnudum* × 565
18. C. *punctulatum* (var. ?) face and base of semicell × 725
19. C. *caelatum* × 630
20. C. *binum* × 630
21. C. *logiense* × 565
22. C. *ochthodes* var. face and top views × 565
23. C. *speciosum* var. *simplex* × 630
24. C. *speciosum*, × 630
25. C. *speciosum* var. *biforme* × 630
26. C. *formulosum* var. *Nathorstii* × 725

(See also Plates XLV, XLVIII, LII, LIV–LV.)

PLATE LIII

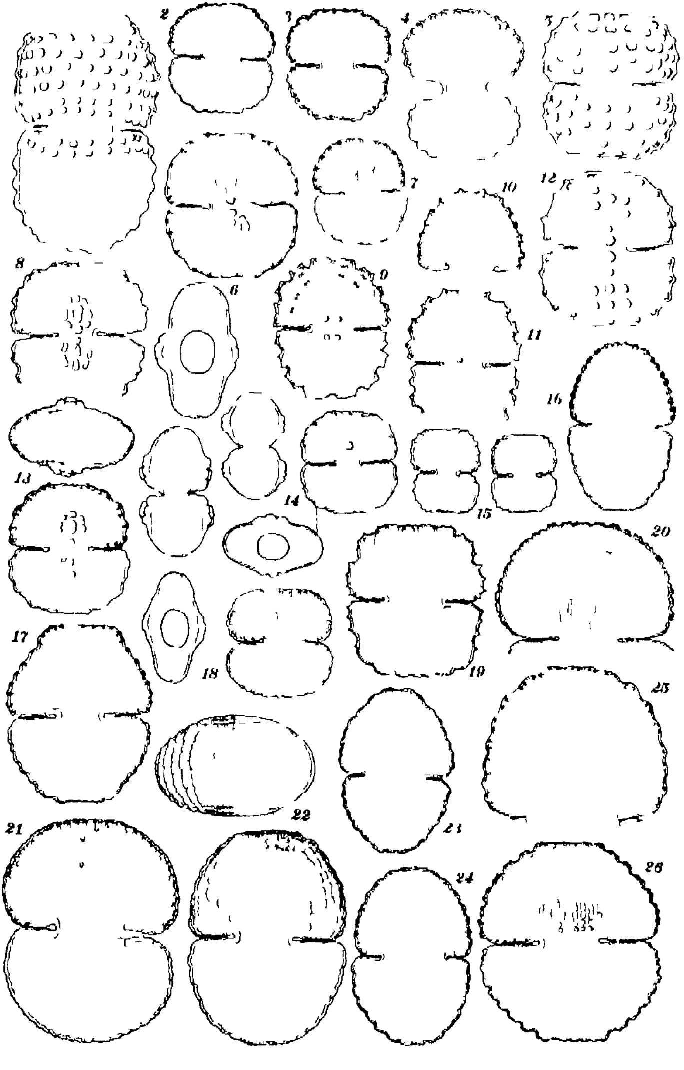


PLATE LIV

Cosmarium

1, 2. *C. sexnotatum* var. *tristriatum*, two cells × 850

3. *C. pseudotaxichondrum* var. *septentrionale*, two cells and basal semicell × 725

4. *C. monomazum* var. *polymazum* × 725

5. *C. subundulatum*, face and edge view × 565

6. *C. taxichondrum* × 525

7, 12. *C. ornatum*, face and top views × 725

8. *C. Longii*, faces of two cells and top view, × 725

9, 11. *C. pseudotaxichondrum* var. *Foggii*, faces of two cells, top and end views × 725

10, 13. *C. quinarium* × 725

14. *C. lagoense*, face and top view × 725

15. *C. Quasillus* × 565

16. *C. protractum*, face and top views × 725

17. *C. laeve* var. *septentrionale* × 725

(See also Plates XLV, XLVIII, LIII, LV.)

Arthrodesmus

18. *A. quadridens*, face of cell and semicell and top view × 725

(See also Plate LVI.)

PLATE LIV

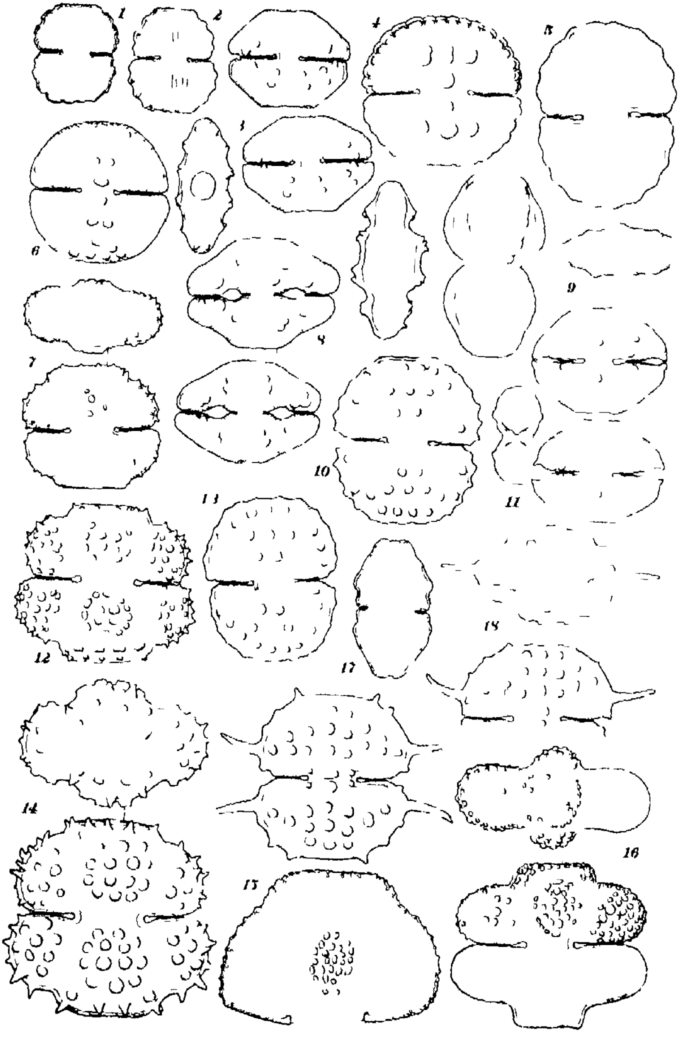


PLATE LV

Cosmarium

1. *C. quadrifarium*, face and top views × 725
2. *C. margaritatum* × 565
3. *C. praegrande* × 385
4. *C. furcatospermum* × 850

5–6. *C. difficile*, f., cell and two semicells × 850

7. *C. pseudoconnatum* × 725
8. *C. viride* × 725
9. *C. ochthodes* var. *amoebum*, face and edge views × 565
10. *C. novae-terrae* × 565
11. *C. impressulum* × 850
12. *C. subcostatum*, × 725

(See also Plates XLV, XLVIII, LIV.)

Xanthidium

13. *X. armatum* var. *cervicorne* × 340
14. *X. armatum* var. *fissum*, semicell and base of semicell × 340

(See also Plates LVI–LVII.)

PLATE IV

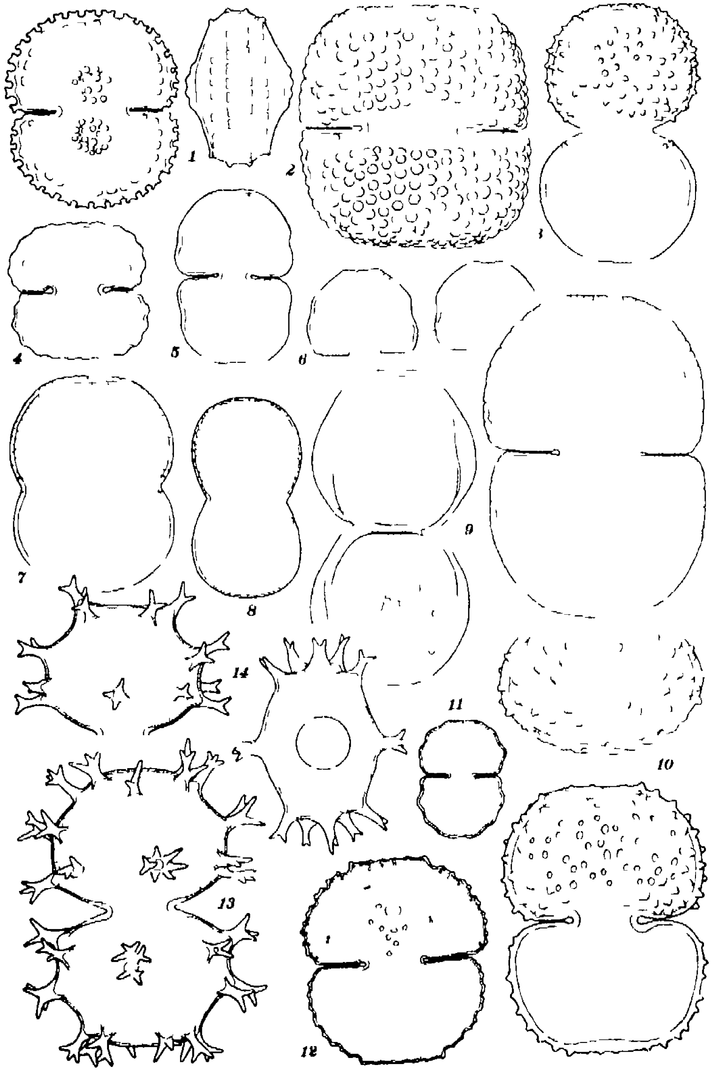


PLATE LVI

Arthrodesmus

1. A. *triangularis* var. *subtriangularis* × 725
2. A. *triangularis* var. *inflatus* × 565

3–5. A. *Incus* var. *extensus*, three cells × 725

6. A. *triangularis* × 725
7. A. *Incus* f. × 725
8. A. *octocornis*, × 725
9. A. *Incus* var. *indentatus* × 725
10. A. *Bulnheimii* var. *subincus*, × 565
11. A. *convergens* × 565
12. A. *impar* × 565

(See also Plate LIV.)

Xanthidium

13–14. X. *Torreyi*, two cells from face view, top and edge views × 565

15. X. *antilopaeum* var. *hebridarum*, face and top views × 470
16. X. *pseudobengalicum* × 565

(See also Plates LV–LVII.)

PLATE LVI

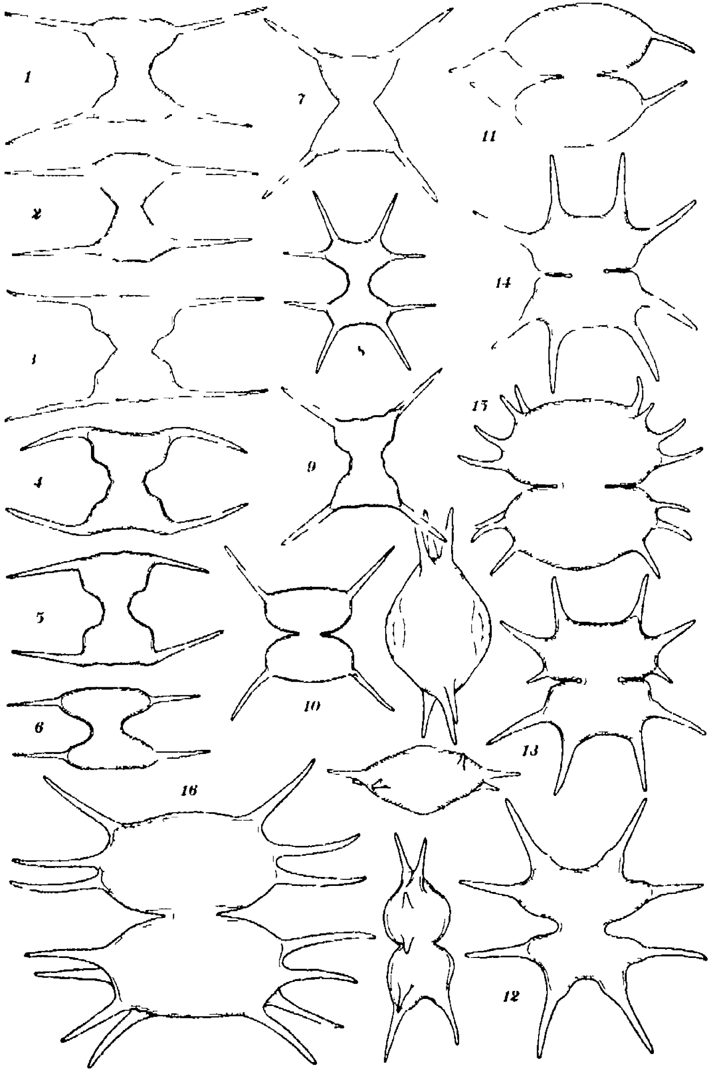


PLATE LVII

Staurastrum[25]

1, 2. *S. aristiferum*, two cells × 725

3. *S. aristiferum* f., face and top views × 565

4. *S. aristiferum* f., face and top views × 725

5, 6. *S. dejectum*, two cells × 725

7, 7a. *S. O'Mearii*, face and top views, × 725

Xanthidium

8. *X. antilopaeum* × 565

9. *X. cristatum* × 565

10. *X. cristatum* var. *uncinatum* × 565

11. *X. antilopaeum* var. *polymazum* × 565

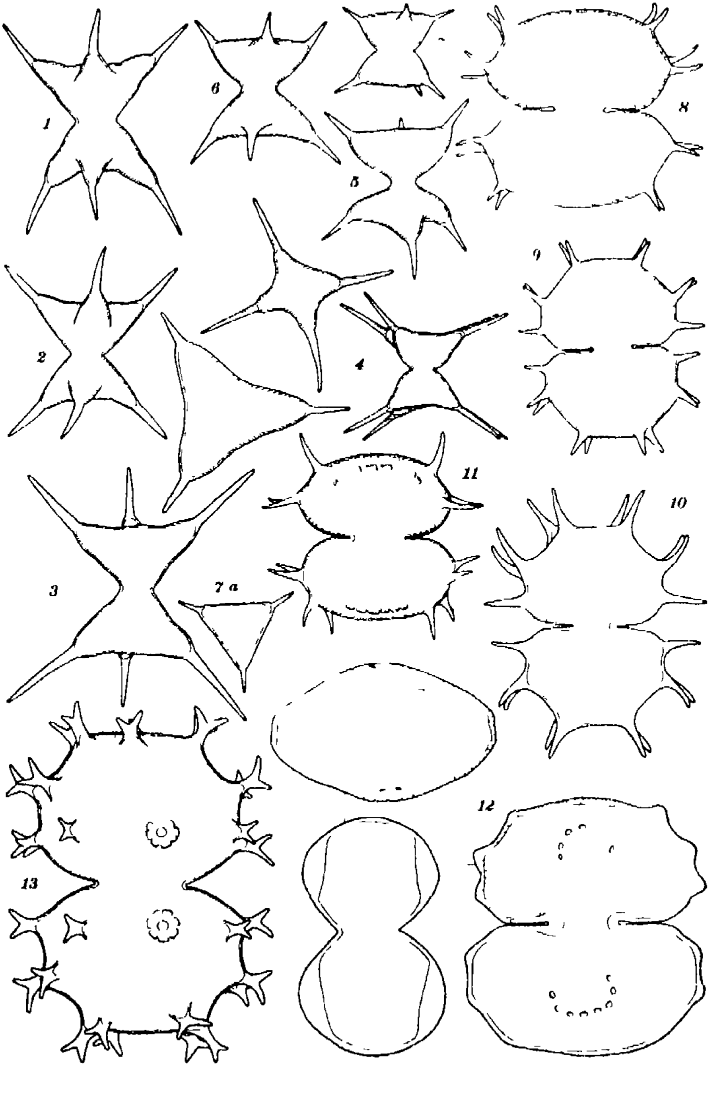
12. *X. obsoletum*, side, top, and vertical section views × 565

13. *X. armatum* × 565

(See also Plates LV–LVI.)

[25] Discussion of these species and illustrations of additional species will appear in Part II of this study.

PLATE LVII



BRYOPHYTES FROM GREENLAND *

FRANCES J THORPE

SINCE the early part of the eighteenth century, when Hans Egede visited Greenland, numerous collections of plant specimens have found their way to the herbaria of Europe and America Disko Island, as well as the coast regions, south, east, and west, and well into the north, has been rather thoroughly covered by botanists In spite of this, almost every collection yields some plant not before gathered in that area or new to science

Mr C O Erlanson collected most of the bryophytes in this list while on the University of Michigan Greenland Expedition of 1927–28 Two years earlier Dr Walter Koelz, naturalist with the Macmillan Arctic Expedition of 1925, sent to the herbarium of the University of Michigan a small collection of 13 mosses from stations on the west coast, most of them from the region around Etah, about 77° N The greater part of Mr Erlanson's collection, numbering 48 mosses and 10 hepatics, came from Disko Island and from the mainland coast and small islands of Disko Bay, between 64° 12′ N and 70° 14′ N A number of his mosses were found in an interesting inland area about 80 miles from the coast at the head of the Söndre Strömfjord between latitudes 66° 50′ N and 67° N, and longitude 50° W and 50° 50′ W This area, on the widest strip of coast unoccupied by inland-ice, is described in a paper on the vascular plants by Erlanson (7) The three divisions of the area are the bog, the heath, and the *fjaeldmark* In the bog only do bryophytes play an important part in the vegetational aspect, although they are common on the heath The bogs yield relatively few species of mosses, but these species often cover large areas Sphagnum (not included in the collection studied) occurs occasionally as an entirely dominant plant, and a few lakes have several species of free-floating moss on the surface

* Papers from the Department of Botany and the Herbarium of the University of Michigan, No 428.

Perhaps the earliest published list of the bryophytes of Greenland is that of Robert Brown (3) The mosses of this collection were identified by M A Lawson and the hepatics by Benjamin Carrington, the total list including 42 mosses and 11 hepatics, most of which were collected at Jacobshavn, 69° N, on the coast of the mainland, in 1867 These specimens, which are to be found in the British Museum, Natural History Division, with many duplicates at the Royal Gardens, Kew, were all examined during the course of the identification of the bryophytes listed in this paper, as well as other Greenland material found in the herbaria named and at the herbarium of Oxford University The private herbarium of Mr H N Dixon of Northampton, England, was also consulted, through the kindness of Mr and Mrs Dixon

In 1875 there appeared a rather exhaustive list of the bryophytes of Disko Island by S Berggren (1), with lists from several other stations This publication proved to be that which is referred to in Macoun's *Catalogue of Canadian Plants* (12) by the puzzling abbreviation "Fl Gr" Morten P Porsild (14) mentions 87 species and varieties of moss collected on Disko Island, and remarks that in comparing the flora of Disko with that of the adjacent parts of the mainland of Greenland we see that it is far richer in species, which is owing to the large contingent of southern species which are peculiar to it " The same author has written a splendid historical survey of the botanical investigations on the Island of Disko (15) Christian Kruuse (11) has discussed the vegetation of east Greenland between 65° 30′ N and 69° 30′ N and lists the bryophytes collected there in 1898 1902 In 1904 Hagen and Porsild (10) described and illustrated 8 species of Bryum Many other articles in *Meddelelser om Grønland* mention species of bryophytes which are found in various parts of Greenland Some interesting species collected by Mr C G Trapnell on the Oxford University Expedition to west Greenland in 1928 are discussed in *The Bryologist* by Dixon (4) This collection was made near Isertutilik at latitude 64° N

A good description of Disko Island and the neighboring mainland, with maps and pictures, is given by Seward (17) in his book on Greenland Professor Seward's chief interest was in securing fossil specimens, so that he named very few of the plants he saw on his trips to the islands and the peninsulas of the mainland He

does, however, mention the presence of "a band of brilliant emerald green moss (*Webera albicans*) that marks the course of a clear stream" as being very noticeable from the Danish Arctic Station at Godhavn, where Mr Porsild is director (17, p 16) Porsild mentions this same thing and lists *Mniobryum albicans* var *glacialis* in his paper on Disko Island vegetation, and Robert Brown includes *Bryum albicans* Brown's specimen seemed to be quite typical *Mniobryum albicans* Unfortunately Mniobryum does not appear in the collections listed here Other good descriptions of stations from which Mr Erlanson collected are to be found in an article by A E Porsild (13, pp 159–167)

The two collections which furnish the material for the following list of bryophytes proved to be, for the most part, well-known Greenland plants Some, however, are of interest because they have been collected infrequently, some show variable specific characteristics, and a few seem not to have been recorded from the stations which Erlanson and Koelz visited A complete duplicate set of Dr Koelz's mosses is deposited in the National Herbarium All of Mr Erlanson's specimens, with the exception of the duplicates sent elsewhere for identification and verification, are in the University of Michigan Herbarium

I am much indebted to Dr A W Evans for the identification of Mr Erlanson's hepatics and to Mr R S Williams for verification of the entire set of specimens of moss collected by Dr Koelz Mr Williams and Mr H N Dixon have most generously assisted with the identification of Mr Erlanson's mosses Mr G B Kaiser gave information about Greenland material in the herbarium of the Sullivant Moss Society Mr Edwin B Bartram helped with suggestions about the literature Mrs F G Britton examined several unusual specimens Mr John Ramsbottom, keeper of botany at the British Museum of Natural History, and Mr W R Sherrin, acting curator of the moss collections, gave me every assistance in the examination of Greenland material I am most grateful to Mr A D Cotton, keeper of the herbarium and library, at the Royal Gardens, Kew, for permission to examine Greenland specimens Mr Sherrin kindly placed the library and herbarium of the South London Botanical Institute at my disposal and gave me technical assistance in examining specimens

The nomenclature of mosses adopted by V F Brotherus (2)

has been followed The hepatics are listed according to Evans' classification (9) Collection numbers cited without the collector's name are Erlanson's

MUSCI

Ditrichaceae

Ceratodon purpureus (L) Brid — On black loam over gneiss, Godhavn, 69° 15′ N , 2819 Heath, Sinigfik, between Skanson and Godhavn, 69° 18′ N , 2981 Heath, Godhavn, 3045 Sandy soil of Heath, Godhavn, 3088

Distichium capillaceum (Sw) Bry eur — Clay beach of lake, head of Söndre Stromfjord, 66° 55′ N , 2450, 2451, 2456 On gneiss, Godhavn, 2770 Etah, 77° N , Koels, 257

Distichium inclinatum (Ehrh) Bry eur — Black humus over old bones at edge of pond, Godhavn, 3084 Sand of stream bank, Atanikerdluk, Nugsuak Peninsula, 70° 02′ N , 3198 Heath, Åtå, Nugsuak Peninsula, 70° 16′ N , 3392

Dicranaceae

Dicranella crispa Schimp — Sandy soil of heath, Godhavn, 3086

Cynodontium polycarpum (Ehrh) Schimp — Black loam, Godhavn, 2821

Cynodontium tenellum (Bry eur) Limpr — Bog, Godhavn, 2918 Over gneiss, Kron Prins Islands, Disko Bay, 69° N , 3507

Dicranoweisia crispula (Hedw) Lindb — Heath, vicinity of Godthaab, 64° 12′ N , 2344 On basalt, Godhavn, 2719 "With the inner perichaetial leaves inclined to be slightly pointed instead of truncate as in most western specimens" — R S Williams Black loam, Godhavn, 2820 On basalt, same station, 2825 Gneiss crevices, Godhavn, same variation as 2719, 2850 On gneiss, Godhavn, 3044 Sandy soil, Godhavn, 3086

Oncophorus virens (Sw) Brid — Black loam, Godhavn, 2853, 2854

Oncophorus Wahlenbergii Brid — In gneiss fissure, vicinity of Godthaab, 2326 Black loam over gneiss, Englishman's Harbour, near Godhavn, June 8, capsules immature, 2893 Bog, Godhavn, June 12, capsules immature, 2920 Heath, Godhavn, 3102 Strand meadow, Åtå, 3378 Over gneiss, Kron Prins Islands, 3504 Heath, Godhavn, 3095

DICRANUM BONJEANI De Not, near var JUNIPERIFOLIUM Broth — Heath, vicinity of Godthaab, 2343

DICRANUM BREVIFOLIUM Lindb — Marsh, Godhavn, 2721

DICRANUM ELONGATUM Schwaegr — On gneiss, Kron Prins Islands, 3505

ENCALYPTACEAE

ENCALYPTA RHABDOCARPA Schwaegr — Humus over basalt, Godhavn, 2716

POTTIACEAE

DIDYMODON RUBELLUS (Hoffm) Bry eur var — Clay beach of lake, Söndre Strömfjord, 2451a Not typical of the species Capsules young

TORTULA MUCRONIFOLIA Schwaegr — On old caribou horn, head of Söndre Strömfjord, 2436 Heath, Sinigfik, 2982

DESMATODON LATIFOLIUS (Hedw) Brid — Sandy loam of heath, Sinigfik, 2980 Bog, Marrak, 69° 20′ N, 2967

POTTIA HEIMII Fuernr (var ?) — Sandy loam of meadow, Atanikerdluk, 3160 Mr R S Williams says that it is apparently a species of Pottia with papillose leaves, but he hesitates to say what species After careful examination it seems to me that it may be one of the varieties of *Pottia Heimii* Fuernr discussed by Dixon (5) The material considered in Dixon's article was collected at Âtâ, very near the station of Erlanson's specimen

GRIMMIACEAE

GRIMMIA CONFERTA Funck — On basalt, Godhavn, 2826

GRIMMIA OVATA Schwaegr — On gneiss, head of Söndre Stromfjord, 2397

RHACOMITRIUM HYPNOIDES (L) Lindb — Cape Hatherton, Koelz, 208 Conical Rock, Koelz, 218

FUNARIACEAE

FUNARIA ARCTICA (Berggr) Kindb — Black loam of stream bank, Kingigtok, Nugsuak Peninsula, 70° 10′ N, 3290

SPLACHNACEAE

TETRAPLODON BRYOIDES (Zoeg) Lindb — Black loam, Godhavn, 2851 Same station, capsules immature, 2852 Rich humus on

shore of pond, Godhavn, 3034 "Mature fresh capsules with strong valerianic odor" — C O Erlanson Erlanson has published an article in *The Bryologist* (8) on the attraction of carrion flies to this species, under the name *Tetraplodon mnioides* Over old bones on black loam of lake edge, Godhavn, 3087 "Capsules odoriferous when fresh" — C O Erlanson

HAPLODON WORMSKJOLDII (Hornem) R Br — Rich humus at edge of pond, Godhavn, 3035 Same station, 3085 The specimen of Robert Brown's *Florula Discoana*, in the British Museum, labeled '*Splachnum sphaericum* Hedw ," proved, upon examination by Mr Sherrin and myself, to be *Haplodon Wormskjoldii*

SPLACHNUM VASCULOSUM L — Rich humus on shore of small pond, Godhavn, 3036 (male plants) Moist meadow, Godhavn, 3046 Black humus over old bones at edge of pond, Godhavn, 3084

BRYACEAE

WEBERA CRUDA (L) Bruch — Bog, head of Söndre Strömfjord, 2466 Shaded gneiss cliff, same station, 2612 Sandy loam, Godhavn, 2924 Sandy loam of heath, Sinigfik, 2980x Heath, Unartok, 69° 55′ N , 3449

WEBERA NUTANS Hedw — Bog, head of Söndre Strömfjord, 2467 Stream bank, Godhavn, 3103 Stream delta, Pâtût, Nugsuak Peninsula, 70° 14′ N , 3334

WEBERA PROLIGERA (Lindb) Kindb — Heath Unartok, 3450

LEPTOBRYUM PYRIFORME Schimp — Clay beach of lake, head of Söndre Strömfjord, 2451x Black loam of stream bank, Kingigtok, 3291 Mud of brook delta, Kingigtok, 3319 Stream delta, Pâtût, 3336 Strand meadow, Âtâ, 3393 Heath, Âtâ, 3417x, 3419 Humus of lake shore, Gronne Island, Disko Bay, 68° 50′ N , 3524

BRYUM CAESPITICIUM L — On old caribou horn, head of Söndre Strömfjord, 2436 An unusual substratum on which to find *B caespiticium* growing, but there was a sufficient deposit of soil in the crevices of the horn for the plants to develop quite normally, apparently Black loam over gneiss, Englishman's Harbour, near Godhavn, 2894 Bog, Godhavn, 2919 Capsules immature, 2921 On granite, Marrak, between Skansen and Godhavn, 69° 20′ N , 2966 Heath, Marrak, capsules immature, 2968 Rich, moist humus, Godhavn, 3037 Heath, Âtâ, 3417

BRYUM GLOBOSUM Lindb — Heath, Âtâ, July 31, 3418 This is a striking moss with its plentiful bright-colored capsules of distinctive shape Dixon (6) has written an interesting account of the species and its var *ruberrimum* To quote from his letter which accompanied the verification of the naming of this specimen "Your Greenland moss is certainly interesting, it is *Bryum globosum* Lindb, which is not recorded from America The rounded, rosy, leptodermous capsules, with a very peculiar exothecium structure, are characteristic I at first thought the leaf structure was wrong, as nearly all the cells were very narrow and scarcely bryoid, but I find that is due to the leaves being scorched or withered, and normal leaves are quite like the European plant This plant is listed by Berggren (1) as *B mamillatum* var *globosum* I believe this specimen collected by Mr Erlanson to be *B globosum* var *ruberrimum* and, if so, this is the first record of that form I have noted In the present plant the capsules are of equal abundance, and of precisely the same form and character, but are of a very bright rosy red, and even in the dry state make an extremely striking object Arnell speaks of the type of *B globosum* as being the greatest ornament of the Arctic zone, but it is certainly far surpassed by this very beautiful variety"

BRYUM INCLINATUM (Sw) Bry eur — Shaded gneiss cliff, head of Söndre Strömfjord, 2611 Humus over basalt, Godhavn, 2716x Heath, Godhavn, 3047

BRYUM INTERMEDIUM Brid — Sandy loam, Atanikerdluk, 3147

BRYUM OBTUSIFOLIUM Lindb — Stream bank, Godhavn, 3096 Wet places, Etah, Koelz, 252 This is a beautiful red moss, apparently with a wide range of stations It seldom fruits, and the two specimens in this list are without capsules

AULACOMNIACEAE

AULACOMNIUM TURGIDUM Schwaegr — Wet bog, head of Söndre Strömfjord, July 13, 2464A This species is common in Greenland, but seldom fruits, according to Berggren (1) There were a few undeveloped sporophytes on this specimen, but no mature capsules

AULACOMNIUM PALUSTRE (L) Schwaegr — Etah, August 7 Koelz, 253

Meeseaceae

Meesea trichodes (L) Spruce — Heath, Naujat, Disko Bay, 70° N , 3193 This is mixed with some species of Drepanocladus Strand meadow, Âtâ, 3379 Meadow, Unartok, 3447

Meesea trichodes alpina Boul — Heath, Unartok, 3452 "With narrower leaves in the upper part, more or less acute " — R S Williams

Catoscopiaceae

Catoscopium nigritum Brid — Black loam of stream bank, Kingigtok, July 21, 3289 This specimen was abundantly fruited and is a distinctive moss

Bartramiaceae

Bartramia ithyphylla Brid — Fissure in gneiss, vicinity of Godthaab, June 27, capsules old and broken, 2325 Shaded gneiss cliff, head of Söndre Strömfjord, 2612 Peaty loam, Godhavn, 2818

Philonotis caespitosa Wils — Godhavn, Koels, 251

Philonotis fontana Brid — Stream bank, Godhavn, 3098 Marsh, Godhavn, 3104

Orthotrichaceae

Orthotrichum Killiasii C M — Clay beach of lake, head of Söndre Strömfjord, 2452

Orthotrichum speciosum Nees — On gneiss, shaded cliff, Godhavn, 2771

Amblystegiaceae

Campylium Cardoti (Ther) Broth — Clay beach of lake, head of Söndre Strömfjord, 2453 Sandy meadow, Atanikerdluk, 3161 This is an unusual moss which I don't find recorded from Greenland "No specimen for comparison " — E G Britton

Drepanocladus Kneiffii var gracilescens Bry eur — In water of lake, Naujat, Disko Bay, 70°, 3195 This is a delicate free-floating form

Calliergon stramineum (Dicks.) Kindb — Igloo da Hauny, Koels, 214 Etah, Koels, 255

Brachytheciaceae

Tomenthypnum nitens var falcifolius Renauld (Variety of *Camptothecium nitens*) — Etah, Koelz, 254, 256, 258 "It is an interesting variety" — R S Williams

Brachythecium plumosum var aquaticum (Funck) Walth & Mol — Bog, Grönne Island, Disko Bay, 3530 "A species of which we had no specimen for comparison" — E G Britton

Polytrichaceae

Pogonatum alpinum (L) Roehl var brevifolium (R Br) Brid (?) — Heath, Skansen, 69° 25′ N, 2949 Not typical Bog, Atanikerdluk, 3267

Polytrichum angustidens Lindb f — Igloo da Hauny, Koelz, 216 Etah, Koelz, 255 This species is synonymous with *Polytrichadelphus Lyallii* Mitt, according to Elizabeth Schenk and T C Frye (16)

Polytrichum hyperboreum R Br — Wet bog, head of Söndre Strömfjord, 2464, 2468, 2618

Polytrichum juniperinum Willd — Heath, Skansen, 2953

Polytrichum piliferum Schreb var Hoppei Rabenh — On gneiss, head of Söndre Strömfjord, 2405

Polytrichum strictum Banks — Wet bog, head of Söndre Strömfjord, 2464 Mixed with *Aulacomnium turgidum* Same locality, 2468 Black loam, Godhavn, May 30, 2842 (male plants) Heath, Unartok, 3453x Conical Rock, Koelz, 219

HEPATICAE

Marchantiales

Clevea hyalina (Sommerf) Lindb — Between mosses, Godhavn, 69° 15′ N, 2808

Peltolepsis grandis Lindb — In moist gneiss clefts, Englishman's Harbour, near Godhavn, 2889 This species "is known in North America only from Greenland," according to A W Evans

Marchantia polymorpha L — Moist stream bank, Godhavn, 3100

JUNGERMANIALES

LOPHOZIA HATCHERI (Evans) Steph — Between mosses, Godhavn, 2809 "Not very typical, but the species seems to be much more variable in arctic and alpine regions than in more temperate localities" — A W Evans Same locality, 2810, 2811

PTILIDIUM CILIARE (L) Nees — Between mosses, Godhavn, 2812 Berggren lists this under the name *Jungermannia quinquedentata* Huds

LOPHOZIA QUINQUEDENTATA (Huds) Cogn — On sandy soil, Godhavn, 2813

SPHENOLOBUS MINUTUS (Crantz) Steph — Wet spot over gneiss, Kron Prins Islands, 69° 15′ N, 3506 Mixed with *Lophozia Hatcheri*

CEPHALOZIA BICUSPIDATA (L) Dum — Wet spot over gneiss, Kron Prins Islands, 3506a Mixed with a little *Scapania lingulata* Buch

SCAPANIA LINGULATA Buch — With *Cephalozia bicuspidata* in wet spot over gneiss, Kron Prins Islands, 3506b "*S lingulata* is a species recently segregated from *S curta*, Buch has already reported it from Greenland" — A W Evans

SCAPANIA SPITZBERGENSIS (Lindb) K Mull — Wet gneiss in crevice, Godhavn, 2840 This is in the same category as *Peltolepsis grandis* in being "known in North America only from Greenland," according to A W Evans

UNIVERSITY OF MICHIGAN

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ABSTRACT OF A PLAN TO PROVIDE SELF-LIQUIDATING UNEMPLOYMENT RELIEF

ERNEST F LLOYD

IT MAY be said with confidence that no possible organization of industry can provide continuous employment for all workers in the trades of their choice and upon their own terms Unemployment relief serves its whole rightful purpose when it takes up only the slack in private employment, as trade responds to the principle of supply and demand This point is emphasized because other political principles are continually and insistently urged in considering the problem and are often injected into it It is assumed that the only sound way to relieve such unemployment is to provide work of a character that is justified by the useful purpose which it will serve It is assumed also that this work must be provided, in the main, by governmental agencies, as distinguished from private effort

It is important that the supplying of such relief employment shall not interfere with the flow of labor to ordinary occupations, or with the rates of pay prevailing in them, that rates of relief pay in different places shall not vary sufficiently to induce migrations of unemployed workers, and that these rates shall be determined without the pressure of political considerations

The financing of such irregular employment requires a certainly available means of a special nature, because there will be frequent calls for relatively small, but not uniform, amounts of money, extending over a considerable period of time, and these advances should be liquidated by charges for the services derived from the labor For these reasons advances by banks, the usual forms of bond issues, tax anticipations, direct taxes, and voluntary contributions are not suitable and sometimes are not available

These various considerations lead to the conclusions (1) that there should be a continuing opportunity to labor — one that may

be availed of without formalities by any worker at any time, (2) that all classes of willing labor should be paid at the same rate, because skill has no commercial value in the absence of industrial demand for it, and (3) that the rate of pay should provide a subsistence, but be otherwise unattractive, so that the work offered will be avoided when other employment can be had

The inconstant volume of this unemployment, the different trades involved in it, and the varying proportions of workers unemployed in these trades require that the relief work be of a character that can be performed manually, that will not suffer from intermittent prosecution, or from changing rates of progress in its execution, and that can be carried on with little capital outlay and upkeep and depreciation charges

The work of building sewage disposal plants is peculiarly suited for unemployment relief These plants are practically all of imperishable construction In the main they are, or may be, of earth embankments and concrete basins A large proportion of the work of construction is excavation, filling in, and the handling of the aggregate of concrete — stone, sand, and cement All this makes possible varying rates of progress without much loss With reasonable skill in the planning and supervision of operations much of the work may be economically done by hand labor Not a little of it must be so done Hand work has the advantage for unemployment relief purposes that it requires a minimum of capital investment, small cost for its upkeep, adaptability to all classes of manual workers, and little effect on efficiency with varying numbers at work Finally, a sewage disposal plant has both long life and continuous usefulness, thereby making possible its self-liquidation and the spreading of the payments over a considerable period

The financing of such projects has heretofore been a chief obstacle to undertaking them in the ordinary way The reluctance of town councils is understandable Public ignorance, apathy, inertia, and the always present fear of added taxes for a purpose which seems remote or unnecessary to the masses, stand heavily in the way

None the less, the right and duty of a state to preserve the general health by requiring municipalities to cease the menace occasioned by the discharge of raw sewage into state waterways would seem to be beyond question Michigan has taken this power, though so far exercising it sparingly This duty often is also an obligation of one

state to another. Therefore, while sewage disposal may be held to be primarily a duty of a municipality to its state, it may be a matter of interstate, and sometimes of international, comity.

Accordingly it is not unreasonable that the state, in its implied obligatory effort to advance the general well-being, should temporarily assist a municipality in so large an undertaking and for such purpose should modify the very proper constitutional provision of some states which, as in Michigan, prohibits the state from lending its credit for local benefits. Particularly may this view be held if the extension of credit for such purpose be primarily and directly to relieve unemployment. For the causes of much of this condition are beyond the control of a municipality, yet the condition itself tends to imperil the state.

If, then, a plan of finance can be drawn whereby indebtedness for such purpose would be incurred by a town only as required for unemployment relief and would be self-liquidating, it would seem that local objections might be lessened, that the state might properly extend its credit in assistance, and be also more exigent in the exercise of its authority in hastening the removal of a stigma upon our American life.

The plan I propose is that the state should authorize the incorporation of an unemployment relief trust company, the capital to be supplied by private subscription. On the board of directors, ex officio and serving without remuneration, should be designated officials of the state. The business of this trust company should be solely that of recouping municipalities for monies paid out by them as unemployment relief in the construction of sewage disposal plants (or other suitable works) under terms prescribed by statute.

The statute would authorize any municipality that had paid out unemployment relief wages at the legal rate in any month, for the building of sewage disposal plant, to apply to the trust company for reimbursement. The trust company would purchase the notes of the municipality as so issued at, say, 95 per cent of par. The notes would bear interest at current rates and be payable, say, twenty years from their dates. A surcharge to meet the interest and amortize the notes would be duly added to the water rates by the municipality and paid to the trust company as collected.

At intervals the trust company might issue series of its twenty-year callable coupon bonds, perhaps in blocks of $100,000. These

bonds the state would guarantee upon assignment and delivery to it of, say, $105,000 of the municipal notes as collateral security

As remittances from the municipalities accumulated the trust company should be required to apply them to the purchase of available bonds, or to call them under their terms, and to cancel and return them to the state in exchange for corresponding notes previously deposited These notes, canceled by the state, would then be returned to the municipalities that had issued them

Upon repayment by a municipality of its entire sum of such notes, the trust company should pay to it one half the profits, in excess of stipulated dividends to the company, that had accrued from the transaction Of the other half of the profits, such proportion as might be prescribed would become a contingent reserve of the trust company Thus the municipality would share reasonably in any profits in excess of permitted dividends to the trust company, while the latter would have an incentive to economical operation

Parenthetically it may be observed that the suggested method of adjusting discounts, interest rates, and surcharges should insure against losses, thereby attracting the funds (from investors who purchase the trust company bonds) which it has become impossible to attract by the credit of the municipalities alone

If and when there should be no further need for such financing, or similar objectives for which the trust company would be available, it would wind up its business and dissolve

I have been purposely sketchy in outlining a plan for applying the principles involved in this study for unemployment relief, because my concern is not primarily with any particular method Plans would no doubt have to vary in different states

It is to be expected that objection will be voiced to a single and low wage for all workers and not less to the individualism that pervades this study But the principles governing value will bear repeating If a man cannot himself find employment for his skill in his chosen trade, at a wage he desires, his skill has no more immediate value to him than has a bushel of apples to its owner in a glutted market It is of even less value, for it passes with the moment, it cannot be stored Equally it may be affirmed that any true method of unemployment relief shall spur the recipient to obtain private work. However much these principles may be disregarded in emergent circumstances, they are fundamental to our

civilization For to concede to the individual the right to support by the state, upon any terms whatever, is to lay the foundation for a new order of political, economic, and social relationships

Beyond doubt much present thought envisages such a right and confidently predicts improved conditions from its establishment But it may well be questioned whether even the ablest minds may ever foresee the ultimate consequences of such a change

The inevitability of some unemployment under the existing economic order and the seriousness of it are fully apparent The quick relief by the dole, in any form, is justifiable only as a necessitous excuse for our collective failure to look ahead, or for the unwillingness of the electorate to select or approve leaders capable of looking ahead and courageous enough to do so, or even, let us say, for human inability to foresee developments and their effects, and to provide against them

Ann Arbor, Michigan

SOME SUGGESTED CHANGES IN THE MICHIGAN TAX STRUCTURE

MATHER FRANCIS THURSTON

ACCORDING to a recent writer on public finance,[1] the essentials of a sound and properly functioning tax system are (1) fiscal adequacy, (2) economy of administration, (3) equity, (4) elasticity, (5) simplicity, (6) diversity, and (7) flexibility

Unquestionably fiscal adequacy must, in theory, be put first, but as a practical matter inequity, real or suspected, may have a serious influence on the productiveness of a supposedly adequate system of taxes Whenever, under a democracy, a considerable number of those who exercise the franchise are convinced that the burden of taxation is unfairly heavy upon themselves, and that there is a reasonable prospect of escaping the burden altogether or of shifting it to others, by delay or refusal to pay, collections will be disappointing[2]

If intelligent changes in any tax structure are to be made, both the need for immediate revenue and the probable future trend of expenditures as well as the yield of present taxes must be known It appears clear that in Michigan more revenue will be needed, both immediately and in the long run, than is likely to be obtainable from present sources The alternatives to new taxation are reduction or abolition of certain essential services, increasing the total of unemployment by curtailing construction projects and dismissing public employees, default on interest and principal of bonds, or refinancing on unfavorable terms The reasonable solution is new taxation Obviously the measures adopted to provide immediate revenue need not, and probably should not, be the same as those designed to be permanent modifications of the tax system Constitutional difficulties, for example, make impossible the immediate adoption of some of the more desirable modifications

[1] Lutz, Harvey Leist *Public Finance*, 2d ed (D Appleton & Co , New York, 1930), p 275

[2] The reaction of Michigan taxpayers to proposals permitting postponement of the payment of delinquent taxes is an example in point Collections fell drastically almost as soon as the discussions began

In 1931 the only taxes other than the general property tax, which produced as much as 1 per cent of the total tax revenues, were the gasoline and weight taxes, yielding about 6 per cent each, the public utility tax, 4 per cent, and the corporation, inheritance, and insurance taxes, which provided respectively 2.1, 1.7, and 1.1 per cent of the total in that year. Since the general property tax in the same year produced 77 per cent of the total, and since the utilities tax is levied on a property-tax basis and at the same rate as the general property tax, the tax limitation amendment, adopted in November, 1932, affected directly the sources from which four fifths of the state and local revenues were drawn. As a consequence, the difficulties of local governments especially in providing for their needs have been greatly increased, and this in spite of the fact that the Supreme Court interpretation of the amendment renders it practically inoperative over a large part of the state. Coupled with tax-relief propaganda and proposed legislative measures, the existence of the amendment has tended to produce a tax-strike psychology, even where levies of the necessary amount can legally be made.

Unquestionably in certain areas and for certain groups of property owners there has recently been genuine difficulty in meeting the property levies. This has not been peculiar to Michigan, but other states with conditions in many respects similar to those of Michigan have long drawn a larger proportion of their revenues from other than property-tax sources. New York, for example, has for years drawn approximately 30 per cent from other sources; no *state* property tax is levied except on certain types of dwellings in New York City which were temporarily exempt from local taxation. The most productive supplementary tax in New York has been the income tax, and it is on increases in the rate of this tax that Governor Lehman is relying for $46,000,000 out of a total of $83,000,000 to be raised by increases in supplementary levies. Since the New York State income tax in 1929 yielded only $84,000,000 and incomes have decreased since then, it is obvious that the proposed increase is a drastic one. It is being made, however, by increases in the base rates and by lowering of exemptions rather than by drastic increases in surtaxes, which probably would have yielded comparatively little additional revenue. An increase of one cent a gallon in the gasoline tax is also suggested, as well as a tax of one per cent on retail sales except food and gasoline. The increases bear lightly on persons

of small means, and the plan seems to be based on collecting taxes from those who have incomes rather than those who have not

As contrasted with this determined effort to provide the necessary revenue from the sources which ought to furnish them, there is at present [3] before the Michigan State Legislature House Bill No 184, described in its brief title as the "General Sales Tax Act" Its scope is actually broader, and it is imposed in the guise of a privilege tax, instead of frankly as a consumption tax, which for the most part it is designed to be The principal levies are as follows A tax of three per cent of the gross sales of commodities or the gross income of businesses, as the case may be, upon persons operating retail mercantile establishments, railroads, public utilities, or theaters, or any other business, occupation, or profession, the taxation of which at a different rate is not provided for in other sections of the act, or which is by the act not exempt from taxation because of the payment of certain specific taxes provided for such types of business by other tax laws specifically cited in the act, [4] a tax of three tenths of one per cent on persons engaged in manufacturing, and of two tenths of one per cent on persons engaged in extractive industries other than agriculture, based on the selling value of the product in each case, and payable after sale

The tax is declared to be an additional tax, levied for the privilege of carrying on such businesses Gross income is defined to mean that part of total gross income actually earned within the state, and the means of determining such proportion are defined Publishers and radio stations are deemed to be manufacturers Exemptions in whole or in part are numerous Wholesalers are specifically exempted from the sales tax, if they are to be taxed on gross income under the blanket provision "any other business, occupation, or profession," that fact is not made clear, nor how gross income would be defined for such purposes Farmers are not to be taxed on their sales, nor are salaried persons or wage earners to be taxed on net income Building and loan organizations, banks, non-profit organisations, religious organisations, agricultural societies, chambers of commerce, and the like are also exempted, as doubtless most of them should be from the nature of their activities, but in other cases the justification for the exemption is not clear

In addition to these total exemptions the bill provides for exemp-

[3] March, 1933 [4] The reader is referred for these to the act itself

tion of the first $4,800 of gross sales or gross income in the case of persons carrying on any business or profession whatever The act is so drawn that this provision operates differentially against *chain* stores (really against their patrons), since only one exemption may be claimed for the entire chain So large a percentage of *independent* stores even in cities do an annual volume of less than $10,000 that a large number of stores in Michigan would escape the tax in whole or in part by virtue of the exemption In cities it is true that such stores do only a small percentage of the total business, but in smaller communities they will do a considerable percentage of it But, since the tax is intended to be passed on to consumers, and doubtless will have to be so passed on if insolvency is to be escaped, the exemption results in a differential levy on consumers Further, a very large percentage of professional men otherwise subject to the tax would escape completely Moreover, the differential application of the exemption in the case of chain stores might be held unconstitutional by the United States Supreme Court In any event the exemptions greatly reduce the yield of the tax

So far, while mentioning certain inequities in the measure, I have been concerned in the main with the question of its productivity The bill is, however, vicious in principle In the first place, so far as the tax on retail sales is concerned, it is disingenuous to call it a privilege tax, since it is intended to operate as a consumption tax and not rest on the operators of stores In the second place, to the extent that the measure might operate at all as a privilege tax it would operate very inequitably, on account of the different ratios of profit to gross sales in different lines Moreover, professional men, in most cases, would find it difficult to pass on the tax, unless by reason of reputation they happened to have a quasi-monopoly in certain fields, but storekeepers would be able to pass on most of it Again, other professional men, who happen to be on a salary instead of operating independently, pay no tax except as consumers Again, that part of the measure which applies to retail sales would as a consumption-tax provision be strongly regressive, and under existing circumstances oppressive

Unfortunately, some sort of general sales tax will probably have to be passed as an emergency measure, if only because it will be difficult to make other taxes yield the requisite revenue on short notice But the rate should be as low as possible, there should be

no exemptions, and the general sales levy should be supplemented by other taxes The following possibilities are suggested

OLD TAXES

Inheritance tax rates might be increased

Corporation privilege taxes might be increased

The gasoline tax might be increased one cent a gallon or two cents, accompanied by a reduction in the weight tax to a nominal figure, the yield of both to be used only for the construction and maintenance of highways

NEW TAXES

Sales taxes

A general sales tax on all retail sales of commodities at a rate not in excess of one per cent on gross sales might be levied, no exemptions being permitted

Luxury surtaxes in the form, perhaps of per unit stamp taxes should be imposed on the sale of luxury grades of ordinary items and on all distinctly luxury types of consumption, at rates of from 5 to 25 per cent ad valorem

Heavy amusement taxes might be levied, perhaps graded according to rate of admission, but based on gross receipts

Heavy taxes should be imposed on tobacco, tobacco products, and such alcoholic liquors as are permitted under the change in the provisions of the federal liquor law

Privilege taxes

A registration fee in the form of a poll tax is proposed, of the amount of $10, ultimately to be collected of all adults but for the present to be imposed only on those whose income from wages, salary, interest, rent or profits, or a combination of these during the last calendar year exceeded $750, or whose gross income from any business in which they were independently engaged during the same year was in excess of $2,500 The registration would be made for police purposes in part, and through the facilities of the police department The payment of the fee would be a prerequisite to employment or to engaging in any economic activity whatever in the state of Michigan

Additional privilege fees for professions might be required of all who engage in any profession or occupation, including business management, whether independently or on salary, whose salaries are in excess of $1,500 a year or whose gross personal income is in excess of $3,000, if self-employed Low, but different rates should be employed for salaries, and for earnings from business operations or professions.

Privilege taxes for corporations, based on gross income might be levied in addition to the present taxes, especially in the case of public utilities In addition such tax as seems desirable might be imposed on the part of the gross output of manufacturers which is sold outside the state and so escapes the one per cent sales tax levy on retail sales.

Heavy liquor license fees should be levied as a means both of revenue and of regulation

Space is lacking to point out in detail the results which would flow from such a system of taxes It should be fairly evident, however, that the general effect is to throw a larger share of the burden

of taxation on those having non-property incomes, or incomes from intangible property, with the maximum burden upon those who engage in either definitely harmful or so-called conspicuous consumption, while taxing lightly, but definitely, all those who have any income whatever It is, of course, expected that the general property tax would continue to furnish, as at present, the bulk of the income for local expenditure It is believed that no constitutional difficulties are involved, though some of the taxes would meet considerable political opposition unless popularized in some way The proposed poll tax, for example, might be earmarked for welfare purposes

Among the possibilities to be considered in connection with a *permanent* revision of the system are the classified property tax, system of sales taxes, and some type of income tax Whatever the merits of a tax on real estate for local purposes, it seems to me that for a state in which as large a percentage of the population have non-property incomes or incomes from intangible property as in Michigan, with another large block dependent upon incomes from tangible property, a properly framed income tax is the best permanent solution of the problem of additional state revenues It probably cannot, however, be adopted without definite constitutional authorization

To avoid the objection of excessive variability, sometimes urged, the tax might be levied on the average net income of two or three years Another possibility is basing the tax on the gross personal income, different rates being used for the various sources, such as salary, interest, rent, or royalties, and for the income from different types of business in the form of profits The income from each incorporated business would be reported as the stockholder's pro rata share of the gross income, and a rate applied which took into account the different typical ratio of profits to gross income for different types of business. Taxation on this basis, which would virtually amount to a tax on *typical* rather than *actual* net income,[8] would tend to force inefficient producers to reform their procedure or quit But whatever basis is adopted, the form must be simple and evasion difficult

University of Detroit
Detroit, Michigan

[8] It is evident, of course, that so far as profits are concerned, the same result could be obtained by similar graded taxes on corporate gross income

SOME RESUPINATE POLYPORES FROM THE REGION OF THE GREAT LAKES V *

DOW V BAXTER

THE studies reported thus far in this series of investigations of resupinate polypores have been concerned largely with keys to the species of the region of the Great Lakes The key to the common white, cinereous, yellow, and red plants was presented in the third paper of this series (1) This was followed by a key to the brown porias and closely related resupinate forms (2) The present paper deals with morphological characteristics of the brown porias and descriptions of the growth features of some of them in culture

The advantages of using color and other growth characteristics of fungi in culture for the purpose of distinguishing between species have been pointed out by Long and Harsch (5) Snell (11) reported that the comparative rates of growth of the mycelium at certain temperatures were valuable criteria in the identification of certain fungi in culture Although it was found, for example, that there was no apparent difference in the optima of growth of two very closely related polypores, *Trametes protracta* Fr and *Lenzites sepiaria*, the upper limits of their growth were very different *L sepiaria* was not inhibited until after 40° C had been reached, whereas *T protracta* was only barely growing at 38° C and showed no growth at 40° C Furthermore, *L sepiaria* was found to grow faster at all temperatures

Tests made with closely allied porias in culture demonstrate that types of growth and growth rates offer valuable characters to follow in distinguishing between certain species in this resupinate group of polypores The porias have been cultured on malt extract agar,[1] and some of these plants have been grown on Czapek's agar, sawdust, and wood blocks as well At least five cultures — usually

* Contribution No 38 from the School of Forestry and Conservation of the University of Michigan

[1] 25 gm agar-agar, 20 gm malt extract, 1000 cc distilled water

more — have been made of each fungus at each temperature used in the experiments — ranging from 5° to 45° C at 5° intervals For the light and dark experiments all cultures of fungi were tested at least in triplicate, usually six or more tests were made with each fungus under each condition The light and dark experiments have all been conducted at room temperature

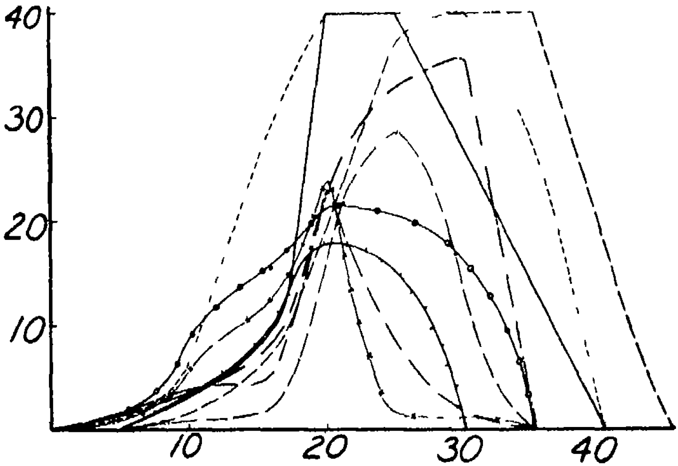

FIG 6 Smoothed curves of the growth of the mycelium of nine resupinate polypores on malt agar in relation to temperature

F ignitarius var *laevigatus* from birch
F ignitarius var *laevigatus* from maple
F ignitarius var *nigricans* from birch
P inermis from winterberry
P prunicola from cherry
P ferruginosa from maple
P ferrea from cherry
P ferrugineo-fusca from hemlock
P ferrea from alder

For convenience and for ready reference I am placing the different porias in classes, arranged according to their reaction in culture (Figs 6–8) Additional tests are being made, the results of which will appear in later numbers of this series of papers

The resupinate plants are classed first as of "rapid growth" or "slow growth" All porias which fill petri dishes in fourteen days at

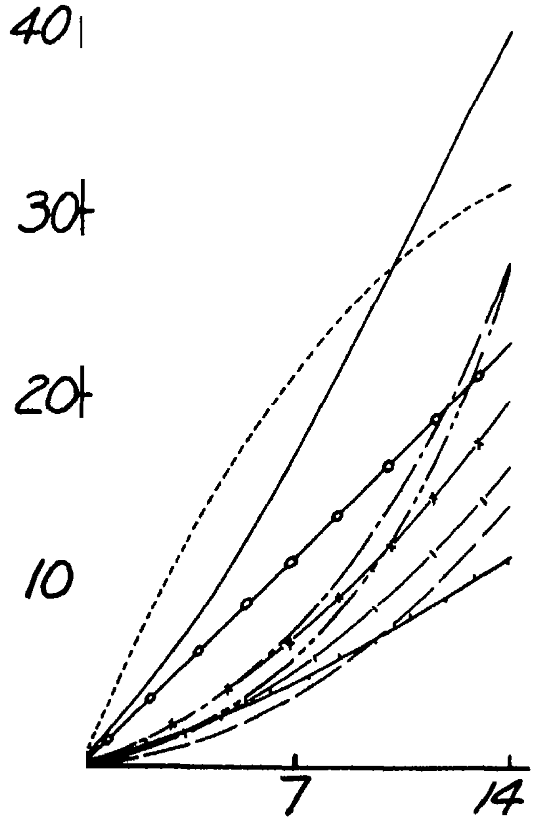

Fig. 7 Smoothed curves of the growth of the mycelium of nine resupinate polypores cultured on malt agar in the dark

P *igniarius* var *laevigatus* from birch
P *igniarius* var *laevigatus* from maple
P *igniarius* var *nigricans* from birch
P *inermis* from winterberry
P *ferrea* from alder
P *prunicola* from cherry
P *ferruginosa* from maple
P *ferrea* from cherry
P *ferrugineo-fusca* from hemlock

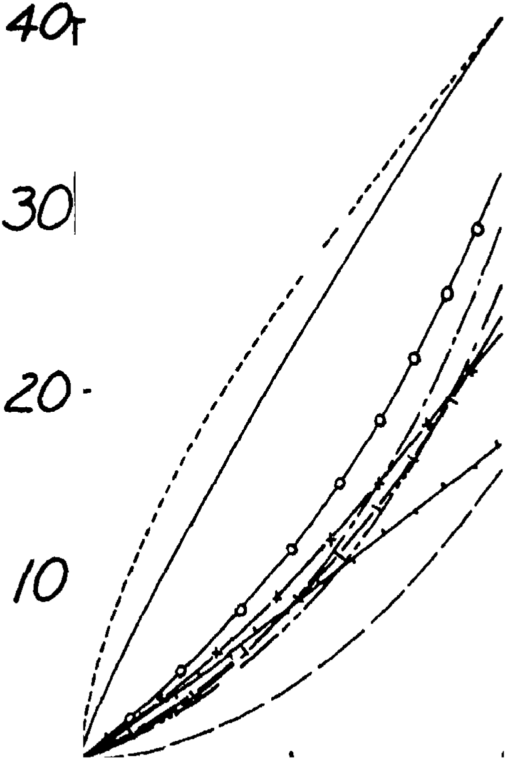

Fig 8 Smoothed curves of the growth of the mycelium of nine resupinate polypores cultured on malt agar in the light

- *P igniarius* var *laevigatus* from birch
- *P igniarius* var *laevigatus* from maple
- *P igniarius* var *nigricans* from birch
- *P inermis* from
- *P ferrea* from alder
- *P prunicola* from cherry
- *P ferruginosa* from maple
- *P ferrea* from cherry
- *P ferrugineo-fusca* from hemlock

the temperature of their optimum growth are placed in the former class In addition, they are grouped according to the temperature range

Those plants exhibiting a growth of 5 mm or more at fourteen days over a range of more than 21° are said to have a "large" temperature range, whereas those exhibiting a range of less than 21° are placed with those in the group classed as the "small" temperature range The porias are also classed according to their optimum temperatures for growth Those that make the best growth at 30° or over within fourteen days are classed in the "high" temperature group, those that make the best growth within this period between 21° and 29°, in the average temperature group, and those at 20° or under, in the low temperature group Plants exhibiting a difference in radial growth of 2 mm or less are said to grow equally well in the light and in the dark

The following groups have been arranged

A RATE OF GROWTH

Rapid growth

Poria inermis from Ilex verticillata	Fomes igniarius var laevigatus (Poria betulina) from Betula alba	Fomes igniarius var laevigatus from Acer saccharum

Slow growth

Poria prunicola from Prunus serotina	Poria ferrea from Prunus serotina	Poria ferrea from Alnus sp
Poria ferruginosa from Acer saccharum	Poria ferruginosa from Thuja occidentalis	Poria ferrugineo-fusca from Tsuga heterophylla
Fomes igniarius var nigricans * from Betula alba		

B RANGE OF TEMPERATURE FOR GROWTH

Large range

Fomes igniarius var laevigatus (Poria betulina) from Betula alba	Fomes igniarius var laevigatus from Acer saccharum	Poria ferrugineo-fusca from Tsuga heterophylla
	Poria inermis from Ilex verticillata	Fomes igniarius var nigricans * from Betula alba

* Very close to line of division

Small range

- Poria prunicola from Prunus serotina
- Poria ferruginosa from Thuja occidentalis
- Poria ferrea from Alnus sp
- Poria ferruginosa from Acer saccharum
- Poria ferrea from Prunus serotina

C TEMPERATURE FOR BEST GROWTH

High temperature

- Poria inermis from Ilex verticillata

Average temperature

- Fomes igniarius var laevigatus (Poria betulina) from Betula alba
- Fomes igniarius var laevigatus from Acer saccharum
- Poria ferrugineo-fusca from Tsuga heterophylla
- Poria prunicola from Prunus serotina
- Fomes igniarius var nigricans

Low temperature

- Poria ferruginosa from Acer saccharum
- Poria ferrea from Prunus serotina
- Poria ferruginosa from Thuja occidentalis
- Poria ferrea from Alnus sp

D EFFECT OF LIGHT

Best growth in dark

- Fomes igniarius var laevigatus (Poria betulina) from Betula alba
- Poria prunicola from Prunus serotina
- Poria ferruginosa from Acer saccharum
- Fomes igniarius var laevigatus from Acer saccharum
- Poria ferrea from Prunus serotina
- Poria ferrugineo-fusca from Tsuga heterophylla

Equally well in light and dark

- Poria ferrea from Alnus sp
- Fomes igniarius var nigricans from Betula alba
- Poria inermis from Ilex verticillata

In the fourth paper of this series color characteristics, texture, effect upon the agar medium, and rate of growth in the dark and light were given for four different resupinate polypores The growth features are presented for seven additional plants in Table I

TABLE I

Growth Characteristics of Brown Polypores on Malt Agar

Name	In Light					In Dark				
	Rate in mm. 14 days*	Color (Ridg.)	Texture	Agar discoloration	Pore formation	Rate in mm. 14 days*	Color (Ridg.)	Texture	Agar discoloration	Pore formation
P laevigata from maple in Michigan	31	Antique brown to buckthorn brown	Granular to flaky	None	None	45	Tawny olive to pinkish buff	Felty	None	None
P inermis from *Ilex verticillata* in Michigan	14	White to buckthorn brown	Cottony	Deeply discolored in 90-day culture	Only porelike formations occur on mycelial mats	16	White to ochraceous-tawny to pale lemon-yellow	Cottony to felty	Black line formation over culture Agar exhibiting discolored zone † in addition	None
P ferruginosa from maple in Michigan	19	White to ochraceous-tawny	Cottony cerebriform	None	Observed in 90-day cultures	18	White to tawny	Cottony cerebriform	None	None
P ferrea from cherry in Michigan	11	Clay color to amber brown	Arachnoid cerebriform	No discoloration within 14 days	None in 21-day cultures	17	White to clay color	Arachnoid cerebriform	No black line and no discolored zone † within 14 days but zone appears in 60-day cultures	None in 21-day cultures
P ferrea from alder in Alaska	21	White to Sayal brown to ochraceous-tawny	Cottony to flaky slightly cerebriform	No discoloration within 14 days	None in 21-day cultures	28	White to ochraceous-tawny to mikado-brown	Cottony slightly cerebriform	No black line formation and no discoloration in 60-day cultures	None in 21-day cultures
P ferruginosa from white cedar in Michigan	13	Light wood brown to tawny olive	Arachnoid cerebriform	None	None		Dark wood brown to Verona brown	Arachnoid cerebriform	No black line formation but slightly discolored zone † evident	None
P ferrugineo-fusca from hemlock in Alaska	14	Walnut-brown to fawn color	Granular to fibrous		Observed in 14-day cultures	23	Prout's brown to hazel	Granular to cottony	None	None

* Cultures grown at room temperature

† Discolored zone refers to area of discolored agar around culture but not to definite black or brown line formation

It can be seen from the groups listed that the majority of the porias reported here fall into the slow growth class In general, those plants which exhibit "slow growth" also have a small temperature range *P ferrugineo-fusca* is the sole exception Only one plant, *P inermis*, falls in the high-temperature group, and *P ferruginosa* again separates itself from *P ferrugineo-fusca* by falling into the low-temperature class

It seems strange that such a common fungus as *P ferruginosa* and one so widely distributed should fall into the slow-growth and small-range classes Attention must be called to the fact that malt agar is used here as the standard for all tests and that with a different medium these fungi might very well fall into different groups Practically all the porias tested exhibit better growth in the dark than they do in the light

DESCRIPTION OF THE RESUPINATE POLYPORES

In addition to the growth studies of the fungi in culture, plants from various sources [2] have been examined for their morphological characteristics The majority of the resupinate polypores studied, however, are to be found in my own collections from this region and from other sections of North America Porias collected on my expeditions to Alaska, the Yukon, and other parts of this continent and in Europe have been studied with reference to those which occur in the region of the Great Lakes and are reported in this series of papers

The records of distribution and also of habitat for the different plants reported in this paper have been prepared, for the most part, from my own collections These records have been supplemented by others obtained from authentic specimens found in the various herbaria already named and from authentic published papers Unless substantiated by other evidence, records of substrata are omitted if wood was not found with the specimens at the various

[2] I am indebted to many individuals for specimens, for help in identification, and for suggestions I am under special obligation to Dr L O Overholts, who has given abundant and unstinted help Acknowledgment is due to Dr Lars Romell, Dr James R. Weir, and others who have identified specimens sent to them for study I wish to express my appreciation to the authorities of the New York State Museum, the New York Botanical Garden, the Division of Pathological Collections in Washington, the Missouri Botanical Garden in St Louis, the Field Museum of Natural History, and the University of Wisconsin Herbarium

herbaria Where errors were detected in the original identification of the wood that record is likewise omitted

Fomes igniarius var *laevigatus* (Fr) Overh

Fomitiporella betulina Murr , North Am Fl , 9 12 1907

Plate LVIII, Figure 1, Plate LIX, Figure 1
(See also Pl XI I, Fig 2, Pl XLII, Fig 2, Pl L Fig 2 of Vol XVII, facing p 439)[1]

Fructification perennial, woody, broadly effused usually up to 10 mm thick, inseparable, margin "Sayal brown" and in weathered specimens becoming "pallid mouse gray", subiculum up to 1 mm thick, tubes stratified, somewhat whitish stuffed, especially in old tube layers, 1–4 mm , mostly 2 mm long each season, mouths generally rounded, 4–6 to a mm , "bay," "chestnut," "auburn" to "buffy citrine," walls thin, basidia 4-spored, 15–17 × 5 μ, spores smooth, hyaline, subglobose or ovoid, (3–5 × 3–4 μ, Romell), setae infrequent, pointed, projecting 8–21 (16 × 4) 4–5 μ, hyphae brown, seldom branched, aseptate, no clamp connections, 2–4 μ in diameter

Allied species — *Fomes igniarius* var *laevigatus* is closely allied to *Fomes igniarius* Romell (9) states that in "*Pol laevigatus*, which in its typical form is a thin, totally resupinate plant, the pores are small (5–7 or 4–8 per mm) with thin walls, while in *Pol igniarius* the pores are a little larger (4–5 or 3–6 per mm) with thicker walls The spores of *Pol laevigatus* are also small (3–5 μ diameter, or 4–5 × 3–4 μ) while in *Pol igniarius* the spores are larger (5–7½ × 4–7 μ), but intermediate sizes are also noted The hymenial spines are about the same in both species "

Poria prunicola has been confused with this species Differences in substrata have been used to distinguish the species, but this test does not seem to me to warrant the separation of the two plants The two plants are distinct in their growth characteristics in culture, however, and should be kept separate

P punctata is difficult to distinguish from *F igniarius* var *laevigatus* Setae are not found in *P punctata*, but they occur in *F igniarius* var *laevigatus*, though they may be infrequent even in this plant Additional differences between the two fungi are exhibited in culture

[1] Such references are to previous volumes in this series.

Cultures — Isolated from *Acer saccharum*, Munising, Michigan, and from *Betula alba*, Superior National Forest, Minnesota *F igniarius* var *laevigatus* belongs to the rapid-growth group of resupinate polypores Although there are certain minor differences in texture, these tests in culture show that the fungus obtained from birch and ordinarily referred to *P betulina* is conspecific with the forms found on other woods and that the name "*betulina*" should not be retained for the plant in question In addition to the similar growth rate exhibited by the plants from the two different substrata, both show a large range of temperature for growth, and both fall in the group of class C, the temperature best for growth The optimum growth is reached at 25° to 30° C When they are grown in the dark, the colors of the cultures from the two sources are the same, but in the light the mycelium of the culture from birch, *P betulina*, was "clay" color, whereas the mycelium of the culture from maple was "antique brown" to "buckthorn brown" Even in these cultures, kept in the light, it can be seen that these color differences are exceedingly slight, since the two colors differ only in very minor shades The rate of growth in the dark is the same for both the maple and the birch fungi, and is practically the same in the light

Fomes igniarius var *laevigatus* exhibits certain differences from the allied *F igniarius* var *nigricans* (resupinate form), *Poria prunicola*, and *P punctata* The first fungus mentioned falls in the rapid-growth class *F igniarius* var *nigricans* grows much more slowly than the *laevigatus* variety, especially in the early periods at low temperatures The optimum temperature conditions for growth are approximately the same for the two plants

F igniarius var *laevigatus* readily separates itself in culture from *P prunicola* *P prunicola* belongs to the slow-growth class and so readily separates itself from *F igniarius* var *laevigatus* Furthermore, *P prunicola* is classed in the small-range category, whereas *F igniarius* var *laevigatus* is in the wide-range group The two fungi, however, exhibit similar requirements with reference to temperatures for best growth

P prunicola is, on the other hand, more closely allied to *F igniarius* var *nigricans* (resupinate form) in its growth char-

acteristics There are no significant distinctions that can be made between these two plants on the basis of temperature ranges, points of optimum growth, and rate of growth *F igniarius* var *nigricans* may be classed as a "border-line" fungus with reference to the groups established The two plants, however, are obviously distinct in their texture and form of growth *F igniarius* var *nigricans* exhibits more of an appressed growth than the former — somewhat leathery in appearance — but *P prunicola* is granular and actually "lumpy" in its type of growth (Pl LX, Fig 1) When transfers are made of *P prunicola* the mycelium frequently peels or separates readily from the agar, so that it is often difficult to make clean-cut sections of inoculum Although this feature depends upon the age of the culture and upon other conditions, it is much easier to make transfers from similarly aged cultures of *F igniarius* var *nigricans*, since this fungus does not separate so easily from the agar substratum

P prunicola and *P punctata* may be separated in culture on the basis of texture and form of growth Both plants exhibit a flocculent aërial mycelium, but the type of growth in *P punctata* is distinctly cottony and not granular or lumpy (Pl LX, Fig 2) *P prunicola* exhibits a granular-lumpy type of growth

Habitat — *Acer saccharum*, *Alnus tenuifolia*, *Betula lutea*, *B occidentalis*, *B nigra*, *Fagus grandifolia*, and *Quercus stellata* (?) It has also been reported on *Rhamnus cathartica*, *alpina*, and *saxatilis* (3)

Distribution — British Columbia, Ontario, Alabama, Idaho, Illinois, Kentucky, Maine, Michigan, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, West Virginia, Wisconsin

Occurrence — Common, especially where birch is found

Decay — The decay caused by this fungus in birch has been studied by Mayr (6) He states that by the end of November the fruiting bodies break through the bark in the form of masses of mycelium as large as the head of a hatpin These masses start their growth from fine cracks in the bark or from lenticels or through the borings caused by *Eccoptogaster* (a bark beetle) The fungus causes a white rot, but brown lines and zones occur in wood decayed by it — the result of the decomposition of the contents of the parenchyma cells of the infected wood such as

the starch and betulin Betulin is found in the form of drops and may or may not be associated with starch The brown discolored wood contains a tannin which may be stained with ferric chloride to greenish brown The fungus is parasitic on birch, according to this investigator The mycelium kills the parenchyma cells, which make up the greater part of the later-formed portions of the annual ring, and as a result of the attack, the rings fall apart or separate from one another in cylindrical pieces

Importance — Mayr states that in Germany this fungus is parasitic upon the birch Although practical foresters are of the opinion that the death of birch may be generally attributed to insects of the families of the *Hylesinae* and *Bosterychinae* and that the fungus is secondary, he believes the poria to be the primary cause of the death of the trees and the insects to be secondary He was unable to decide definitely about the exact relationship between the fungus and the insects, but did observe that the borings provided points for the formation of the fruiting bodies of the poria and also that the mycelium offered palatable food for the insects He recognizes the facts that the activities of insects accelerate the decomposition of the wood and that, when occurring in great numbers, they often attack healthy trees as well as those already diseased, but he maintains that in general the fungus is the chief cause of the death of the trees These items are significant and offer valuable suggestions to students concerned about the death of birch in this country, especially where the bronze birch borer is associated with this poria. In America *F igniarius* var *laevigatus* is usually found on fallen timber and is not regarded as parasitic In fact, *F igniarius* var *nigricans*, and not *F igniarius* var *laevigatus*, is the common fungus which causes decay in standing birch trees in the region of the Great Lakes The determination of the exact relationship between *F igniarius* var *nigricans*, or perhaps some of the other fungi on birch such as *F fomentarius* (regarded generally in Europe as a parasite) and *Pol betulinus*, and the bronze birch borer should supplement Mayr's work on "*Pol laevigatus*"

Fomes nigrolimitatus (Romell) Egeland, Nyt Mag, 52 135 1914

Polyporus nigrolimitatus Romell, Arkiv für Bot, 11 18 1911
Phellinus nigrolimitatus (Romell) Bourd & Gals, Hymen Fr, 1–622 1927
Fomes putearius Weir, Journ Agric Res, 2 163 1914

(See Pl XLV of Vol XVII, facing p 439)

Fructification perennial, corky, resupinate or effused-reflexed, covering the side or under side of fallen trees for a distance of two feet and sometimes more than two feet Usually up to 1–1 5 cm thick, sometimes thicker, when reflexed, surface of pileus at first soft, azonate, tomentose, and, when young, "bay," and becoming black with age, context soft and punky "Sudan brown," in resupinate plants 1 5–10 mm thick, but varying with the irregularities of the substratum, thin black line less than 1 mm thick appearing in context, tubes becoming stratified and separated by a narrow context which exhibits the black line or the tube layers stratified and not apparently separated by a context layer, tubes 0 5–9 mm, mostly 6 mm long each season, "Sayal brown", mouths rounded or angular "avellaneous" to "Sayal brown" to "snuff brown," averaging 3–6, mostly 4–5 to a mm, walls thick, basidia hyaline, 2–4-spored, 8–14 × 4–5 μ, spores hyaline — possibly becoming brown — but hyaline in all of my specimens, smooth, cylindric, 4–6 × 1 5–2 μ, setae brown, occasional, pointed, 13–29 × 4–9 μ, hyphae brown, seldom branched, mostly aseptate, hyphae of the trama occasionally septate, no clamp connections, 2–5 5 μ in diameter

Allied species — *Fomes putearius* Weir is considered to be conspecific with *F nigrolimitatus* until a plant having spores similar to those described for *F putearius* is discovered and additional studies of this plant are made The spores of *F putearius* have been found by Overholts (8) to be hyaline and not colored, as described, and measure 4–5 × 3–4 μ The spores of *F nigrolimitatus* are cylindric, 4–6 × 1 5–2 μ Shope (10) states that he was unable to find spores in the type collection of *F putearius* Weir (12) described them as "colored, globose, smooth, 7 to 8 μ" Bourdot and Galzin (3) state that the spores of "*P nigrolimitatus*" are hyaline, then brown This might very well account for the different determinations of spore color, but, of course,

does not explain the difference in spore types A specimen of *F nigrolimitatus* Romell from Colorado, determined by Romell, is in my collections

F nigrolimitatus might be confused with *Poria Weirii* The differences between the two species are discussed under "*Poria Weirii*," page 329

Habitat — *Larix occidentalis*, *Picea Engelmanni*, *Pinus contorta*, *P ponderosa*, *Pseudotsuga taxifolia*, *Tsuga heterophylla*, *T Mertensiana* It is also reported on *Thuja plicata* (4) and *P silvestris* (9)

Distribution — Alaska, Colorado, Idaho, Oregon, Washington, Wyoming, also found in Norway, Sweden, and on the main European continent

Occurrence — Common on fallen logs in the north Pacific slope, the coastal forests of Alaska, Inland Empire region, and in general the northern and central Rocky Mountain districts

Decay — *F nigrolimitatus* produces a well-defined type of decay which is readily distinguished from most rots Wood rotted by this fungus is most nearly similar to that decomposed by *Fomes Pini* Thore ex Lloyd, but the white pockets are much larger Their size depends somewhat upon the structure of the wood In *Pinus ponderosa* the pockets are smaller and more oval than they are in *Larix occidentalis*, in Douglas fir they are broadly oval *Picea Engelmanni* decayed by this fungus exhibits smaller pockets than those in any of the other woods (12)

Importance — This fungus produces a common rot of snags and fallen coniferous timber

Fomes pomaceus Pers forma *Crataegi*, Baxter, Am Journ Bot, 12 563 1925

Plate LXI

(See also Pl XLVIII of Vol XVII, facing p 439)

Fructification perennial, woody, growing singly, but often confluent, 4–7 cm long, 1 5–2 5 cm wide, and 0 5–1 5 cm thick, margin 0 5–3 0 mm broad, thick, abrupt, "warm buff" to "amber brown," tomentose, becoming glabrous and horny, turning "drab" to "hair brown" to "chaetura drab" after wintering, subiculum "cinnamon-brown", tubes indistinctly stratified, 4–6 mm long each season, whitish stuffed, mouths rounded,

walls thick, 5–6 to a mm, "ochraceous-tawny" to "cinnamon-brown", basidia hyaline, 9–11 × 3–7 μ, spores hyaline, globose, 5–6 μ in diameter, setae brown, not abundant, and sometimes entirely absent, 11–17 × 4–7 μ, hyphae brown, unbranched, aseptate, no clamp connections, 2–3 μ in diameter

Allied species — The fungus possesses the microscopic features of *F pomaceus*, but the form retains the resupinate habit of growth The growth of this form on Crataegus has been followed for several years on trees in the vicinity of Ann Arbor, but the typical fruiting bodies of *F pomaceus* have never been found on this species here *P prunicola* is easily distinguished from the plant in question, even though both are found on Prunus The thick, abrupt, horny "drab" to "chaetura drab" margin of *F pomaceus* forma *Crataegi* and the narrow growth form of the fruiting structure of this plant readily separate the two species

Cultures — Isolated from *Crataegus sp*, Ann Arbor, Michigan, from *Prunus americana*, Ann Arbor, Michigan The difference in species of trees from which the fungi were obtained did not affect the growth characteristics of the mycelium in culture Furthermore, there were no appreciable differences between cultures obtained from decayed wood and those secured from fruiting bodies The mycelium is at first whitish It soon turns to "maize yellow," later becoming "cinnamon-brown" In eighteen-month-old cultures kept in the diffuse light of the laboratory the color darkens to "snuff brown" The mycelium is at first floccose in young cultures, but later the cultures become lacunose in appearance

Habitat — Gregarious on various species of Crataegus and on *Prunus americana*

Distribution — Illinois, Kentucky, Michigan, North Carolina

Occurrence — Common in southern Michigan

Decay — Cross-sections of the infected trees show a decided color contrast between the sound or apparently sound wood and that which is noticeably rotten The normal reddish brown wood of a healthy trunk is rapidly changed to a much lighter color by the action of the fungus. In outline these areas are irregular, extending outward from the center in a finger-like manner In some trees apparently sound areas may remain as scattered and completely surrounded by the visible rot The size of the de-

cayed area increases, and finally both heartwood and sapwood are destroyed As the rot progresses radially in all directions, the rather small amount of the spring wood remaining undecayed stands out in the form of slight ridges This is, in fact, a unique macroscopic characteristic effect produced by the fungus on the host If infected wood is split lengthwise, the sound portions show a relatively smooth surface in contrast with the roughened or uneven appearance of the areas rotted by the fungus, not only in the heartwood but in the sapwood as well The wood fibers and vessels are the first cells attacked

The absence of concentric black lines or zones in either the radial or cross-section is a characteristic feature of this rot

All sections taken from the distinctly rotten wood exhibit the presence of abundant mycelium The vessels are frequently filled with hyphae, and no difficulty is experienced in locating mycelium in the wood cells

Importance — Although the host species may be important for landscape planting, no great importance is to be attached to the rot

Poria ferrea Pers , Myc Eur , 89 1825

Mucronoporus fulvidus E. & E , Proc Acad Nat Sci Phila , 1894 323

Plate LXII, Figure 1, Plate LXIII

Fructification perennial, at times effused on decorticated wood or bark for as much as 2 meters, or frequently found in rounded spots, 0 2–6 cm or even larger, sometimes separating naturally at the margins in old specimens, plant usually up to 7 mm thick, margin sterile, tomentose, up to 1 mm broad, "clay color" to "snuff brown", subiculum usually thin, less than 0 5 mm thick, tubes in one layer or stratified 1–3 5 mm long each season, mouths "tawny-olive," subrounded to subangular, thick-walled, entire, ranging 4–6, mostly 5 to a mm , basidia 2–4 spored, 11–14 × 4–6 μ, spores narrow, cylindric, 5–7 × 2–2 5 μ, setae brown, gradually tapering to a narrow sharp point and projecting 11–34 μ beyond the basidia, 4–6 μ wide, no cystidia, hyphae brown, mostly unbranched and aseptate, no clamp connections, 2–3 μ in diameter

Allied species — *Poria ferrea* reminds one of *Poria ferruginosa* (Schrad) Fr The spore characters of the two plants are, however,

distinctive features In *P ferrea* the spores are cylindric, 5–7 × 2–2 5 μ, whereas those of *P ferruginosa* are globose-ellipsoidal, 4–5 (4 × 3) 2 5–4 μ

Cultures — Isolated from *Alnus tenuifolia*, Skagway, Alaska, from *Prunus serotina*, Munising, Michigan The growth characteristics of this poria in culture are presented in Table I There is little difference between the growth features of *P ferrea* and *P ferruginosa* in culture Attention is called to the fact that the mycelium of *P ferrea* is more characteristically reddish brown (at least in areas) than the clay color of *P ferruginosa* Both fungi soon produce a cerebriform growth in the agar cultures (distinctive for this group and unlike many of the brown porias in culture), this characteristic is inclined to be more clearly marked in cultures of *P ferruginosa* Pore formation takes place in younger cultures of *P ferruginosa* than in those of *P ferrea*, but in both of these fungi much later than in cultures of *P ferrugineo-fusca*

P ferrea belongs to the slow-growth group of porias It exhibits growth within a small range of temperatures The maximum development of *P ferrea* occurs at 20°

Habitat — *Acer rubrum*, *A spicatum*, *Alnus tenuifolia* (very common on these genera), *Betula occidentalis*, *Cornus Nuttallii*, *Gleditsia triacanthos*, *Populus tremuloides*, *Salix sp* Known also on Castanea, Quercus (8), Corylus, Fagus, and Prunus

Distribution — British Columbia, Nova Scotia, Alaska, California, Idaho, Illinois, Michigan, Montana, Oregon, Washington, West Virginia

Occurrence — Apparently more abundant in northern Michigan and in other northern sections of the United States than in other regions of the country In the north it occurs more frequently than the allied *P ferruginosa* *P ferrea* is the common poria found on the alder which grows on the "delta river" sites in Alaska

Decay — Typical white rot

Importance — One of the chief destroyers of small slash in moist woods It rapidly destroys the standing wood of the replaced temporary species such as willows, alders, and maples, which have been crowded out by the succeeding forest type

Poria ferrugineo-fusca Karst

Poria marginella (Peck) Sacc in Syll Fung 9 194 1891

Plate LVIII, Figure 2

Fructification annual or perennial, corky, effused for several inches on wood and bark of substratum, usually not more than 6 mm thick, inseparable, tomentose, light-colored or whitish margin in fresh plants, becoming "Sudan brown," typically 1 mm wide in mature specimens, but often several millimeters wide, "tawny-olive" subiculum conspicuous, up to 1 mm thick, tubes 2–4 mm long, mouths "snuff brown" to "warm sepia," averaging 5–6, mostly 5 to a mm, walls thick, entire, basidia 3–4 × 11–15 μ, spores smooth, hyaline, allantoid, 4–5 × 2 μ, setae abundant, not conspicuous, projecting 22–40 μ, and 3–6 μ wide, bluntly pointed, hyphae dark brown, thick-walled, mostly unbranched, cross walls infrequent, no clamp connections, 2–3 μ in diameter

Allied species — This species is readily distinguished from *P ferruginosa* by the smaller spores The more or less cinnamon color of the tubes and the marginal characteristics of the growing plant are also distinctive

Cultures — Isolated from *Tsuga heterophylla*, Skagway, Alaska The chief features of this fungus in culture are presented in Table I and Figures 6–8 The colors of the mycelium in agar cultures are very similar to those produced in nature on wood The whitish marginal features, the color of the rest of the mycelium, the lack of the cerebriform growth so characteristic in cultures of *Poria ferruginosa* and the tendency to produce tubes in younger cultures and much more readily are additional characters which may be used to separate *P ferrugineo-fusca* from *P ferruginosa*

P ferrugineo-fusca belongs to the slow-growth group of porias Its optimum growth takes place at 20°–25° C

Habitat — *Abies grandis, A lasiocarpa, A magnifica shastensis, Pinus Banksiana, P contorta, P echinata, P monticola, P ponderosa, P Taeda, Pseudotsuga taxifolia, Larix laricina, L occidentalis, L Lyallii*

Distribution — Alabama, Alaska, California, Idaho, Indiana, Michigan, Minnesota, Montana, New York, Ohio, Wyoming

Occurrence — Common, especially in the western coniferous forests

Decay — Yellow ring rot Shallow white pockets appear in the spring wood of the decayed layers

Importance — The fungus occurs on fallen logs and logging débris

Poria ferruginosa (Schrad) Fr , Syst Myc , 1 378 1821

Polyporus Macounii Peck Bot Gaz , 4 169 1879
Fuscoporia ferruginosa (Schrad) Murr , North Am Fl 9 5 1905
Poria Macounii (Pk) Overh , Bull New York State Mus 71 86 1917

Plate LXII Figure 2, Plate LXIV

(See also Pl XLVI Fig 1 of Vol XVII, facing p 439)

Fructification annual or perennial, corky, broadly effused on decorticated wood or on bark for a distance of 3 meters at times, but usually not more than 0 5 meters, 0 5 6 mm thick margin 0 5–1 mm broad when young, at first sterile, but becoming fertile when mature, subiculum usually not more than 1 mm thick, "cinnamon-brown", tubes in one layer or stratified 1 2 5, mostly 1–2 mm long each season, often becoming somewhat imbricate when growing on bark, mouths "snuff brown" to "Sayal brown," usually without sheen, unchanging in herbarium specimens, or subangular to subrounded, 3 6, mostly 4 5 to a mm , dissepiments thin at maturity, basidia 4-spored, 10–14 × 4–5 μ, spores globose or ellipsoidal 4 5 (4 × 3) 2 5–4 μ, setae brown, abundant, sharp-pointed, usually projecting 11–30 μ, occasionally as much as 40 μ, 4–8 μ broad at their bases, hyphae brown, unbranched, aseptate, no clamp connections, 2-4 μ in diameter

Allied species — *P ferruginosa* may be differentiated from *P ferrea* by the spore characters The spores of *P ferrea* are cylindric, 5–7 × 2–2 5 μ, whereas those of *P ferruginosa* are globose-ellipsoidal, 4–5 (4 × 3) 2 5-4 μ The affinities of *P ferruginosa* are also with *Trametes isabellina* These two species may also be separated by the spore characters The spores of *T isabellina* are 6-9 × 2, according to Shope The setae project much farther beyond the basidia in *T isabellina* (50 μ) than those of *P ferruginosa* (30 μ or less — occasionally as much as 40 μ)

Cultures — Isolated from log of *Thuja occidentalis*, International Falls, Minnesota, and from *Acer saccharum*, Munising, Michigan *Poria ferruginosa* makes its best growth at approximately 20° C and attains its growth in a narrow range of temperatures There

is practically no growth exhibited above 25° C This plant is placed in the slow-growth group of porias Cultures made from different substrata exhibit no significant differences Tube formation is found in 90-day cultures The rate of tube formation in *P ferruginosa* is much slower in cultures than that of *P ferrugineo-fusca*, and is much faster than in the closely allied *P ferrea* This feature will readily separate *P ferrea* from *P ferruginosa* and may be used to supplement the difference in spore character when the two plants are to be distinguished

Habitat — *Acer macrophyllum*, *A Negundo*, *A saccharum*, *Abies lasiocarpa* (?), *Alnus oregona*, *A tenuifolia*, *Amelanchier canadensis*, *Arbutus Menziesii*, *Betula papyrifera alba*, *B lutea*, *Castanea dentata*, *Fagus grandifolia*, *Fraxinus nigra*, *Halesia carolina*, *Gleditsia triacanthos*, *Juglans nigra*, *Magnolia acuminata*, *Ostrya virginiana*, *Physiocarpus opulifolius*, *Picea mariana*, *Populus angustifolia*, *Quercus borealis*, *Q Gambelii*, *Robinia Pseudo-Acacia*, *Salix sp*, *Sassafras varifolium*, *Thuja occidentalis*, *Tilia americana*

Distribution — British Columbia, Manitoba, Ontario, Alabama, Alaska, Colorado, Idaho, Illinois, Iowa, Kentucky, Maine, Michigan, Missouri, New Hampshire, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Virginia, Washington, West Virginia, Wisconsin

Occurrence — On standing dead hardwood trees, especially alder, cherry, and willow, and on various species of hardwood logs and slashings It is common in moist woods on dead standing chestnut sprouts *P ferruginosa* is found frequently on logs of *Thuja occidentalis*, but it is not usual on any coniferous wood except white cedar

Decay — White rot

Importance — One of the common destroyers of hardwood slash in moist woods

Poria inermis E & E, Proc Acad Nat Sci Phila, 1894 322

Plate LIX, Figure 2

Fructification perennial, firm but neither woody nor corky, effused sometimes for two or three feet in elongated patches, cracking

open in deep fissures upon drying or in old specimens, mostly on dead standing trunks, inseparable, margin narrow, sterile 0 5-1 mm wide, "ochraceous-tawny" in old plants (because of the receding growth), outer tube layers become black and form a margin up to 5 mm wide and upon drying this margin naturally separates itself from substratum, subiculum thin, ordinarily less than 0 5 mm wide and inconspicuous, brown, tubes mostly oblique, not stratified, 1-4 mm long, mouths "antique brown" to "Dresden brown," weathering to "raw umber," subrounded to subangular, walls thin, entire, averaging 4-6 to a mm, basidia 13 × 2-6 μ, spores brown, smooth, globose, or ellipsoid, flattened on one side 5-6 × 3-4 5 μ, setae none, hyphae brown, 2-3 μ, mostly unbranched, cross walls present in light brown hyphae, no clamp connections

Allied species — *Poria inermis* is not readily confused with any of the other brown porias The brown spores and the lack of setae in this fungus readily separate it from the other members of the genus

Cultures — Isolated from *Ilex verticillata*, Whitmore Lake, Michigan Growth characteristics of this poria are presented in Table I and Figures 6 8 This fungus belongs to the rapid-growth class and has a relatively high optimum of growth, attaining its maximum at 30° to 35° C This is the highest temperature of maximum growth recorded for any of the brown porias thus far tested Furthermore, the range of temperature for growth is larger than it is for the majority of porias tested Small rounded depressions, which resemble pore formation, appear in the mats of mycelium, but these are, for the most part, caused by the evaporation of the drops of liquid which appear on the surface of the culture

Habitat — *Ilex verticillata*, *Nemopanthes mucronata* Reported also on Alnus and Cornus (8)

Distribution — Illinois, Kansas, Louisiana, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, New York, Pennsylvania, Virginia

Occurrence — Very abundant in Michigan bogs

Decay — White rot

Importance — The chief fungus which causes decay in standing *Ilex verticillata*

Poria prunicola (Murr) Sacc & Trott in Sacc , Syll Fung , 21 331 1912

Fomitiporia prunicola Murr , North Am Fl 9 9 1907

Plate LXI

(See also Pl XI I, Fig 3, Pl XIII Fig 3, Pl XIIX, Pl I , Fig 1 of Vol XVII, facing p 439)

Fructification perennial, appearing first in circular areas which finally merge, plant becoming widely effused, sometimes for 3 meters, mostly adnate, but often loosening slightly at the margins from the substratum, up to 15 mm thick margin narrow, 0 5 mm , tomentose, and "tawny" at first, disappearing in old plants or occurring at edge of new layers in plants where receding growth has taken place, the old margin and tubes near margin in such plants becoming "gray" or "light gull gray" to blackish, subiculum thin, usually less than 0 5 mm and mostly disappearing with age, tubes 1-2 mm long each season, whitened within in the old layers, indistinctly stratified, mouths "avellaneous" to "Verona brown ' to "Saccardo's umber," becoming gray in old weathered plants, subrounded, thick-walled, entire, averaging 4-6 to a mm , basidia 8-10 × 4-6 μ, spores hyaline, smooth, ellipsoid or globose 4 5 × 3-4 μ, setae rare, usually short, 8-13 × 4-5 5 μ, hyphae brown, simple, aseptate, no clamp connections, 2 μ in diameter

Allied species — This plant is closely allied to and most readily confused with *Fomes igniarius* var *laevigatus* The small spores cannot be used to distinguish the two species, since in the typical "*Pol laevigatus*" as interpreted by Romell (9) the spores are also small "3-5 μ diam or 4-5 × 3-4 μ" It has been pointed out in the present paper that the spores of *P prunicola* are 4-5 × 3-4 μ The small narrow hymenial setae suggest themselves as possible characters to follow in separating the two species, but measurements made from numerous collections of *F igniarius* var *laevigatus* demonstrate that the setae of this species are often just as narrow The form of growth on cherry and the usually large parts of the fruiting body becoming gray in old weathered specimens, in combination with the small spores and narrow setae, may often be used to indicate the species, but each character breaks down and is an unreliable

guide when studied by itself The two species are distinct, however, and are readily separated in culture The differences are described in the next paragraph

Cultures — Isolated from dead standing *Prunus serotina*, Grand Island, Michigan *Poria prunicola* belongs to the slow-growth class The colors of the two plants when grown in the light are different, *P prunicola* being "tawny-olive" and *F nigricans* var *laevigatus* "antique brown" to "buckthorn brown" As the cultures age, the color differences are even more marked In twelve-week-old cultures *F ignarius* var *laevigatus* appears to assume the color characteristics of the marginal growth found in plants in nature An appressed mat formed over the surface of the agar gives a thick texture *P prunicola* retains its brown color and its flocculent characteristics in cultures of the same age

P prunicola attains its best growth at approximately 25° C It exhibits one of the slowest growth rates of all of the porias — based upon growth at optimum temperature for a two-week period Furthermore, the temperature range is rather narrow, being about 10° to 30° C The growth in the dark is more rapid than in the light See Table I and Figures 6 8

Habitat — *Alnus sp* , *Prunus pennsylvanica, P serotina*

Distribution — Manitoba, Michigan, New Hampshire, New York

Occurrence — Common in northern Michigan, particularly in moist maple-birch forests where cherry is found Here one can readily collect large masses of material, some of which extend two or three feet or more along dead standing snags in the forest They are particularly common on wood that is from about three to eight inches in diameter Not common in southern Michigan

Decay — White rot The decayed areas of the exposed parts of the wood are frequently overgrown by the brown mycelium to such an extent that the entire material may appear brown rather than white

Importance — One of the chief causes of slash rot in this genus in northern Michigan It is found on both dead standing trees and fallen material

Poria tsugina (Murr) Sacc & Trott in Sacc , Syll Fung , 21 332 1912

(See Pl I, Figs. 1–2, Pl V, Pl VI, Fig 1 of Vol VI, facing p 76)

Fructification perennial, broadly effused, sometimes for a distance of two feet, adnate when in fresh growing condition, in old dried plants sometimes separating from the substratum, commonly up to 55 mm thick and observed in specimen from Summit, Oregon, 65 mm thick, margin "chamois" at first, as much as 1 mm wide, adnate, irregular, sterile, tomentose and finally disappearing, or becoming a part of a broad, thick sterile margin sometimes up to 65 mm wide, at first "clay color," but becoming "fuscous" and finally "chaetura black", subiculum not more than 1 mm thick and largely disappearing between the tube layers in old specimens, tubes usually distinctly stratified, frequently as much as 15 layers, 2–8, mostly 4 mm long each season, somewhat whitish stuffed in the old layers, mouths 4–7, mostly 5–6 to a mm , "ochraceous-tawny," to "tawny-olive," and "wood brown," subangular to subrounded, thick walls, entire, basidia 11–15 × 5 5–9 μ, spores smooth, hyaline, globose, or subglobose, 5 8 μ in diameter, setae none, hyphae brown, simple, aseptate, no clamp, no clamp connections, 2–4 μ in diameter

Allied species — The characters of diagnostic value are the same in *P tsugina* and *F robustus* The spore measurements are similar, the color and context seem to be the same There are no setae in either plant *P tsugina* is considered to be a resupinate form of this species

Cultures — The mycelium is "light buff" in young cultures and varies from this color to "yellow ocher" and "buckthorn brown" in one-year-old cultures The mycelium formed brownish strands on hemlock block cultures or grew out from the sides and ends of the blocks as white or buff-colored mycelium The hyphae on a malt extract medium are not so uniform in width as those found in decayed wood In culture they vary from 1 μ to the larger and more or less bulbous portions, which measure 5 5 μ in width The hyphal ends and parts of the individual cells are frequently swollen, the swollen parts become occasionally chlamydosporic in appearance These much-branched hyphae may be hyaline or brown The fungus discolored the malt agar

by changing it to a dark brown This color is the same as that of the dark lines which may be observed frequently in the form of circles or rings in the decayed wood

Habitat — *Tsuga canadensis*, *T heterophylla* It has been reported on Picea and Pinus (8)

Distribution — Alaska, California, Colorado, Idaho, Michigan, New Hampshire, New Jersey, New York, Ohio, Oregon, Pennsylvania, Wisconsin

Occurrence — Common in regions where hemlock is found

Decay — Tangential sections of the wood rotted by this poria are characterised by a white mottled appearance in the early stages of decay This mottled effect is produced by the occurrence of white areas at first scattered throughout the summer wood As the rot progresses, the areas increase in size, and the remaining cells, decayed to a less degree, may then appear as small irregularly scattered brown spots In radial section, white lines or zones may be observed in the summer wood region as a result of a continued coalescing of the white areas The white areas almost or completely separate the annual ring There is then a tendency for the hemlock wood to break into flat pieces upon drying or under pressure, the slabs correspond to the annual rings

Fine and much-branched hyphae, which measure less than 1 μ in width, occur in these broken-down regions

Importance — A common destroyer of hemlock slash The fungus is found most frequently on the lower surface of limbs (2 or 4 inches in diameter) which cling to the fallen hemlock trunk

Poria Weirii Murr , Mycologia, 6 94 1914

Fomitiporia Weirii Murr Mycologia, 6 93 1914.

Plate LXV, Figures 1–2

Fructification perennial, corky, light in weight, effused in long flat layers on the under side of the fallen trunk or attached to the root crotches of living western red cedar trees, up to 12 mm thick, but usually about 7 mm , separating readily from the substratum, margin sterile, tomentose, 1–2, mostly 1 mm wide in young plants and often disappearing with age, subiculum "cinnamon-brown," punky, usually 1 mm wide, tubes stratified,

2 5 mm long each season, not whitish stuffed, the tube layers easily separated from each other, mouths "wood brown" to "benzo brown," angular, thin-walled at maturity, entire, averaging 4 6, mostly 5 *to* a mm , basidia hyaline, 4–7 × 10–13 μ, spores smooth, hyaline, globose or subglobose (4–6 μ in diameter, Overh) setae thick-walled, brown, mostly incrusted, and tapering to a point, 22–50 × 4–8 μ, and embedded setal hyphae numerous — usually tapering as setae in the hymenial layer, hyphae occasionally branched, cross walls present, no clamp connections

Allied species — This fungus is clearly distinct from other species The light, corky-spongy nature of the fruiting body, the large incrusted setae, the abundance of setal hyphae, and the readiness with which the tube layers can be separated are the important items of distinction *Fomes nigrolimitatus*, which is also found in this western region, causes a large white pocket rot in hemlock, larch, spruce, and other species This rot is distinct from the ring rot similar to that resulting from the decay of western red cedar caused by *P Weirii* The black lines which appear in the older parts of the context of the fruiting bodies of *F nigrolimitatus* and the lack of setae, which are incrusted (setae are present, however, in this plant), are also distinctive characters to be used in separating the two fungi

Habitat — *Thuja plicata* Although the fungus has been reported on *Thuja occidentalis* (4), it is undoubtedly so rare on this species that it is unlikely to appear in any collections In spite of the fact that a special study has been made of the fungi which decay eastern white cedar in Michigan, I have never found *P Weirii* on this wood There are no records of it on white cedar in the University of Michigan herbarium *Poria ferruginosa*, on the other hand, is common on this species

Distribution — British Columbia, Alaska, Idaho, Oregon

Occurrence — Common in Idaho

Decay — The early stages of decay in the heartwood are first indicated by yellowish brown discolorations, which deepen as the decay advances The spring wood of each annual ring decays first, resulting in a laminated appearance The rings readily separate from one another, forming a typical ring rot Brown wefts of mycelium are often to be found between the ring layers The rot appears at the ends of logs in crescent to circular form

According to Hubert (4), the rot is rarely found extending up the full length of the trunk, but frequently reaches from five to ten feet up into the butt log. The roots are usually decayed, as the rot develops, the butt section of the tree becomes hollow.

Importance — This fungus causes a common ring-scale rot in the basal sections of the western red cedar and probably induces the greater part of the butt rot found in this species. It entails considerable loss of sound material and is responsible for a certain amount of windfall and wind breakage in this species of tree. Decay continues to develop in the heartwood and sapwood after the tree has fallen. The rot may occur on one side of the tree, but the other side may be sound. The fungus probably gains entrance through fire scars.

Trametes carbonaria (B. & C.) Overh.

Hexagonia carbonaria B. & C., Grevillea 1: 68. 1872.
Fuscoporia carbonaria (B. & C.) Murr. North Am. Fl. 9: 4. 1907.
Trametes Sequoiae Copeland, Ann. Myc. 2: 507. 1904.

(See Pl. XXVI of Vol. IX, facing p. 46.)

Fructification annual, coriaceous, effused, usually in patches for about 10 cm., sometimes as much as 22 cm., and exhibiting an interrupted growth form, mostly on charred wood, 1.5–3 mm. thick, separable, margin fertile, subiculum inconspicuous, less than 0.5 mm., and largely disappearing in age, "snuff brown", tubes in one layer, 2–3, mostly 2 mm. long, whitish pruinose within, mouths "wood brown" to "bister," unchanging in herbarium specimens, hexagonal, averaging 1–2 to a mm., walls thin, entire, somewhat tomentose, basidia hyaline, 5–7 μ in diameter, four-spored, spores smooth, hyaline 6–9 × 2.5–3 μ. setae none, unbranched, aseptate, no clamp connections, 2–3 μ in diameter.

Allied species — This plant is easily distinguished from any other member of this genus or of the genus Poria. The name "carbonaria," however, should not be confused with "carbonacea," which is the name given to a very different fungus, "*Polyporus carbonaceus*" B. & C., or "*Melanoporella carbonacea*" (B. & C.) Murr.

Habitat — *Chamaecyparis Lawsoniana, Larix occidentalis, L. laricina, Pinus monticola, P. ponderosa, P. Taeda, Sequoia sempervirens, Thuja occidentalis, T. plicata.*

Distribution — British Columbia, Alabama, Arizona, California, Florida, Idaho, Michigan, Montana, New Mexico, New York, Oregon, South Carolina, South Dakota, Washington

Occurrence — Occasional, always on charred wood

Decay — Associated with a brown cubical rot on charred logs

Importance — Decay of slash, chiefly found on the logs rather than on the small branches

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PL A

FIG 1 *Fomes igniarius* var *laevigatus* from *Acer saccharum* Twenty four-day-old culture on malt agar Pale mouse gray to aniline black

FIG 2 *Fomes ferrugineo-fusca* (*P. marginella*) from *Tsuga heterophylla* Twenty four-day-old culture on malt agar Avellaneous to vinaceous tawny

PLATE LIX

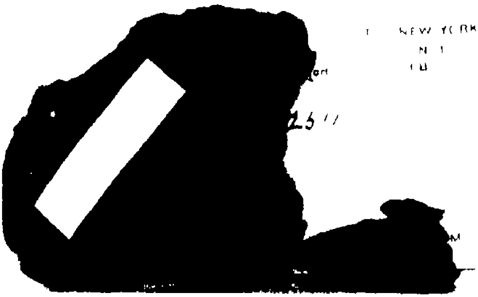


Fig. 1. *Fomitiporella betulina* Murr. Type specimen on birch (*Fomes igniarius* var. *laevigatus*)

Fig. 2. *Poria inermis* E. & E. on *Ilex verticillata*. Whitmore Lake, Michigan

FIG. 1. *Fomes igniarius* var. *nigricans* from *Betula alba*. Twenty four-day-old culture on malt agar. Chamois to tawny-olive.

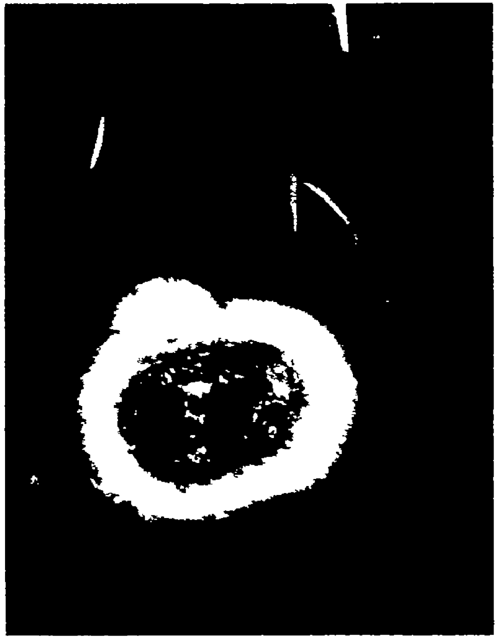
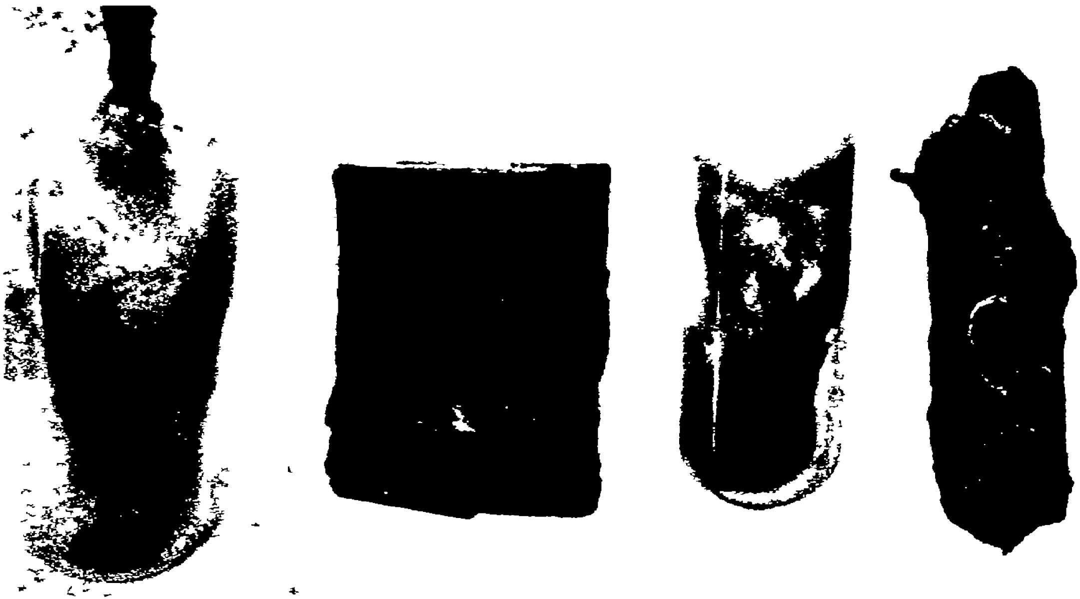


FIG. 2. [illegible] from [illegible]. Twenty four-day-old culture on malt agar. Cream buff to Isabella color.

PLATE LXI



F. ... pruinicola from *Prunus serotina* (left) and *F. ... pomaceus forma Crataegi* from *Crataegus* (right) in culture on malt agar. Note black line which appears in the culture from *F. ... pomaceus forma Crataegi*.

A

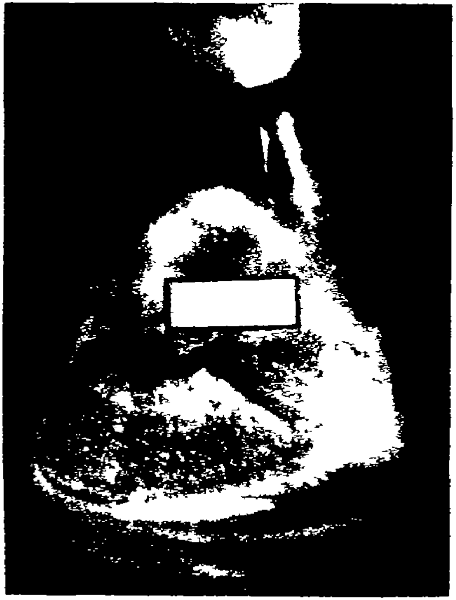


FIG. 1. *P[illegible]* [illegible] from *Alnus* sp. Seventeen-day-old culture on malt agar. Warm buff to russet.

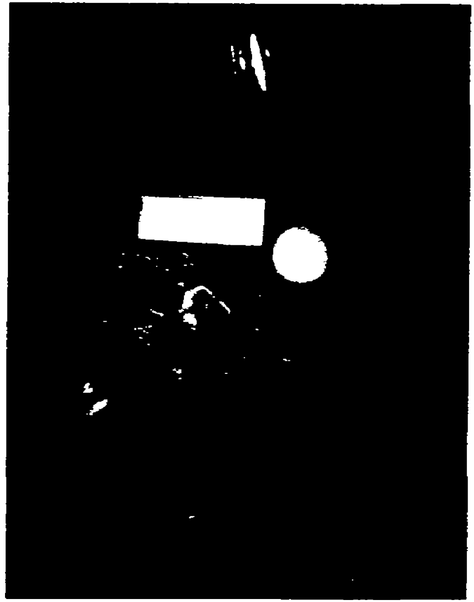


FIG. 2. *[illegible]* from *Acer saccharum*. Twenty-four-day-old cultures on malt agar. Light ochraceous-buff to tawny.

PLATE LXIII

Poria ferrea Pers. ex Romell on *Alnus sp.* Skagway, Alaska

PLATE LXIV

[illegible] Ann Arbor, Michigan. [illegible]
Note stratification of tabula layers in the specimen.

PLATE LXV

Fig. 1. *Poria Weirii* (Murr.) Sacc. & Trott. on *Thuja*. Note distinct layering of tubes.

Fig. 2. *Poria Weirii* (Murr.) Sacc. & Trott. on *Thuja plicata*. Nelson, British Columbia.

DEERYARDS OF THE UPPER PENINSULA OF MICHIGAN

MAX C WAKEMAN

AN INTENSIVE study of Michigan deeryards has been going on for only five years In the late fall of 1927 all the Upper Peninsula conservation officers and local sportsmen's organizations were asked to report to the Department of Conservation all the best deeryards known to them During the winter of 1927–28 ten of the most important so reported were sketch-mapped by Department field men under the supervision of Bartlett and Stephenson, of the Game Division, and three yarding areas were mapped in detail by them In mapping deer population the approximate number of deer in each degree of concentration, as determined by their method, follows scattering, approximately 5 deer per 40 acres, light, approximately 10 deer per 40 acres, medium, approximately 30 deer per 40 acres, and heavy, none observed [1]

The winter of 1928–29 was very severe, and deer were yarded in practically all parts of the Upper Peninsula During this winter three of the more important known deeryards were visited, and what is probably one of the best in the Upper Peninsula, the Cusino, was mapped in detail

The winter of 1930–31 was somewhat less severe than the preceding one The principal deeryards were again looked over and an additional yard, the Chandler Brook in Marquette County, was mapped in detail

The winter of 1931–32 was mild, the snow did not exceed three feet in depth in a large part of the Upper Peninsula Many yarding areas were visited that year, but, because of the relatively light depth of snow, deer in the majority of these yards were not concentrated to any extent

Since the winter of 1932–33 was extremely mild, it was the latter

[1] Bartlett, Ilo H, and Stephenson, Joseph H, "A Preliminary Survey of Deeryards in the Upper Peninsula of Michigan," *Pap Mich Acad Sci, Arts and Letters*, 10 (1928) 411–416 1929

part of February before any great depth of snow was apparent in the Upper Peninsula deeryards The Game Division did not have trained men in the Upper Peninsula to investigate deer-yarding conditions until the latter part of March

A brief account of some of the more important deeryards in the Upper Peninsula follows

HULBERT DEERYARD

The Hulbert deeryard, located in Chippewa County immediately north of the town of Hulbert, contains approximately 29,000 acres of the swamp along the east branch of the Tahquamenon River The principal cover types within the yard are cedar, spruce, tamarack, and alder

During the latter part of February and the first part of March, 1928, Stephenson and Bartlett made a detailed investigation of a part of this deeryard Cover and concentration maps were made of 10,240 acres in Township 46 North, Range 6 West

That part of the swamp which lies west and north of the town of Hulbert has relatively good cover and feed in comparison with the rest It was thought that this section would contain the most deer, and it was picked as the area to be mapped It was found later, however, that the majority of deer were using the poorer part of the swamp as the principal yarding ground and that a large number of them were concentrated around a small logging operation, approximately four miles north and east of Hulbert When the cutting stopped the deer were stranded without food, since the exceedingly deep snow of that winter prevented their moving to better locations, In the spring between fifty and sixty deer were found dead in the vicinity of these cuttings, presumably from starvation or exposure, or both

There was no logging in this deeryard during the winter of 1928–29, and deer remained in small scattered groups throughout the swamp The snow was quite deep, but the deer were not concentrated and apparently they survived the winter in good shape

During the winter of 1929–30 approximately four hundred deer were concentrated around the same logging operations where they were found in March, 1928 The cutting was completed during the latter part of February Within a week these deer had eaten practically all the available browse Since there was danger of starva-

tion, the Department of Conservation fed them from February 23 to April 12, when the spring break-up came

Practically the same conditions prevailed during the winter of 1930–31 as during the previous winter Cutting operations were carried on in the same place until the latter part of January Deer were gradually drawn in to the fresh cuttings The snow was not of sufficient depth to cause them to remain, but they did, and since it was entirely possible that heavy snow would come later and the deer would then be unable to scatter out, the Department of Conservation fed them from February 7 until April 10 It is possible that because deer were fed here during the previous winter they might have come back with the expectancy of being fed again This is only an assumption, however

These deer were trapped and tagged as they were being fed, in order to give us some data, if possible, on the extent of their movements away from the yard, also, if deer were to be fed here in the near future, to give information concerning the number of deer which would come back to a place where they had previously been fed

The winters of 1931–32 and 1932–33 were very mild, and very few deer yarded in the Hulbert swamp There are, however, a large number of deer which use this yard as their winter range In severe winters starvation and death from exposure are likely to result because of the lack of sufficient browse and cover

McMILLAN DEERYARD

The McMillan deeryard is located in Township 46 North, Ranges 11 and 12 West, just north of the town of McMillan, in Luce County It is very similar in character to the Hulbert deeryard, since it is an extension of the same swamp The principal cover types are spruce, cedar, tamarack, and alder, the spruce-cedar type predominates

Logging operations have been going on in this yard for approximately twenty years, and it is reported that, at the present rate of cutting, the major part of the swamp will be logged out within the next few years The amount of cover and browse is now materially reduced, if these logging operations do continue, the cover and browse will be practically gone when the logging is completed

This yard cares for a very large number of deer whose summer range is the hardwood and plains country to the north

Concentration maps have never been made of the McMillan yard,

but the Michigan Land Economic Survey farm-forest maps are available Reconnaissance trips taken through the yard during various yarding seasons have shown that there was a serious scarcity of cedar browse There is hardwood browse along the swamp borders, but during periods of deep snow this is inaccessible The cut-over parts contain little or no browse, the uncut areas of cedar and spruce are self-pruned and overbrowsed to such an extent that very little food is left within reach of the deer The swamp also has large sections of pure spruce, tamarack, and alder, which contain little, if any, browse

Slashings from logging operations have supplied the deer with food during the past, but when these are gone, with the food and cover seriously depleted, some measures will eventually need to be taken to care for the deer during the more severe winters

CUSINO DEERYARD

The Cusino deeryard is located in Alger and Schoolcraft counties, approximately fourteen miles east of Munising The yarding area lies in Township 47 North, Ranges 16 and 17 West, and Township 46 North, Ranges 16 and 17 West

A detailed survey of this yard was made by Bartlett and Wakeman in February, 1929 The following maps were made cover, showing the type, stocking, and average diameter of the various cover types, concentration, giving the approximate concentration of deer in the various parts of the yard, and feed, showing the comparative amounts of available cedar browse

Over 37,000 acres were mapped in this yard and the country immediately surrounding it Thirty per cent of the area is virgin hardwood, 15 per cent cut-over hardwood, 31 per cent conifer swamp, and the remaining 24 per cent is divided into small areas of hardwood swamp, alder, sedge marsh, poplar, and upland grass

From the concentration maps it was found that approximately 3,773 individuals were present in the 12,800 acres which deer were using This indicates about 189 deer per square mile

The best of this yarding area and the surrounding country has recently been purchased by the Department of Conservation for the purpose of saving it from cutting A state game refuge, including the principal yarding area, has been established The surrounding country is available as public hunting ground

CHANDLER BROOK DEERYARD

The Chandler Brook deeryard is located within Township 44 North, Range 26 West, Marquette County, just south and west of the town of Gwinn

A detailed survey of this yard was made by Wakeman and Cahalane in January and February, 1930 A cover map, concentration map, and feed map were made

This area does not lie in the "deep snow belt" of the Upper Peninsula Snow here during an average winter is seldom more than three feet in depth Deer concentrate in the vicinity of the yarding swamps, using them principally for cover Most of the browsing is done in the hardwood second growth surrounding these areas, except in very severe weather, when deer are unable to get to it

Over 22,000 acres were mapped in this yard and the country immediately surrounding it Fifty-four per cent of the area is conifer swamp, 17 per cent hardwood second growth, 22 per cent poplar, and the remaining 7 per cent is divided into small areas of pine, fire cherry, and upland grass

The concentration map shows that 57 per cent of the total area had no deer, 27 per cent, a scattering concentration, 15 per cent, a light concentration, and 1 per cent, a medium concentration This gives a total of approximately 1,820 deer or about 50 per square mile

The feed map shows that 25 per cent of the entire area contains little or no winter feed Forty-eight per cent contained available winter feed, of which 27 per cent was cedar browse and 21 per cent hardwood browse

The swamp is in very little danger of cutting, since practically all of the yarding area is now state-owned Since this deeryard was mapped it has been combined with the two townships to the west to form the as yet undeveloped "Escanaba River Tract"

BEAVER LAKE DEERYARD

The Beaver Lake deeryard, lying in what is known as the Beaver Lake Basin, Township 48 North, Range 16 West, Alger County, was surveyed in March, 1928, by Bartlett and Stephenson

An area of 8,182 acres was mapped in detail, of which 3,500 acres were found to be mixed cedar-spruce swamp, 3,000 of virgin hardwood, 875 of white birch, and approximately 1,000 of lakes and

streams It was estimated that there were not over one hundred deer using the yarding area

The swamp in this area is very well suited for deer-yarding, affording excellent cover and good browse

CISCO LAKE DEERYARD

A detailed investigation of part of the Cisco Lake deeryard was made by Bartlett and Stephenson in January and February, 1928 The area mapped comprises the eastern two thirds of Township 45 North, Range 41 West, Gogebic County

This is typical of the kind of yarding area found in the western part of the Upper Peninsula It differs from the yards in the eastern part in that instead of deer being concentrated in the conifer swamps they are scattered throughout the areas of mixed hardwood and hemlock as well as the swamps

Detailed maps were made of 15,360 acres, showing the character of the cover and the approximate deer concentration The upland timber is a combination of maple, hemlock, and yellow birch, with an understory, in many places, of cedar, spruce, and balsam This type comprises 48 per cent of the total area

The swamp timber is principally cedar, spruce, balsam, and tamarack This type covers 36 per cent of the area Comparatively fresh slashings comprise the remaining 16 per cent

The general condition of the browse throughout the entire yard was found to be very good It was estimated that there were approximately 3,139 deer, an average of 131 per square mile This yard is apparently in no immediate danger from cutting or over-browsing

OTHER DEERYARDS

During the winter of 1927–28 the following deeryards, which cover approximately 117,000 acres, were mapped by the Department field men Little Girls Point, Gogebic County, Middle Branch, Ontonagon County, Falls River, Baraga County, Whitbeck, Marquette County, Sturgeon River, Dickinson County, Sturgeon River, Delta County, McMillan, Luce County, Trout Lake, Chippewa County, Carp River, Mackinac County, and Paint River, Iron County

In addition, five deeryards, covering approximately 34,500 acres, have been visited and reported on during the past four years, but

no detailed survey was made They are the High Rollways, Schoolcraft County, Haywire, Schoolcraft County, Sturgeon River, Baraga County, Skanee area, Baraga County, and Sand River, Alger County

To date eighty-three other yarding areas, covering approximately 436,200 acres, have been reported to the Game Division They have never been investigated Some of them undoubtedly are important and should be looked at in the future

SUMMARY

Since 1927, when an intensive study of Upper Peninsula deeryards was started, five of the most important yarding areas have been investigated in detail A complete report, with cover and concentration maps, was made of each deeryard In addition, maps showing the relative amount and kind of browse were made of the Cusino and Chandler Brook yards

Ten deeryards, involving approximately 117,000 acres, have been given a preliminary investigation by Department field men Brief reports were prepared for each yard, accompanied by sketch maps of cover and concentration

Reconnaissance surveys and reports have been made for five additional yards, involving an approximate total of 34,500 acres

Because of the relatively mild weather prevailing during the winters of 1931-32 and 1932-33 no deeryard studies were made Many of the yarding areas which have been given only a preliminary survey need a much more detailed investigation

Some of the problems which come up in connection with deeryards and which need further study are

1 Accurate census methods

2 Information on the home range of deer by live-trapping and tagging operations

3 The planting of various species of trees for browse

4 The management of deer in badly cut-over and browsed-out yards

These problems can be worked out only by intensive study over a period of years

Department of Conservation Game Division
Lansing, Michigan

THE GROWTH OF *OSTRYA VIRGINIANA* *

LEIGH J YOUNG

IN ANY list of species that are regarded as offering profitable possibilities from the standpoint of forest management, ironwood, or hornbeam, *Ostrya virginiana* (Mill) Koch, is usually omitted Not only is it rated inferior, but it is definitely considered a "weed" species, one to be eliminated as nearly as possible from any woods in which it happens to be present

This opinion of its undesirability seems to be based entirely on general observations rather than on any definite studies of its characteristics

In judging the possibilities of any species the following characteristics should be determined technical qualities of the wood, susceptibility to various forms of damage, size and form, rate of growth, site requirements, effects upon the site, and reproductive ability

In most of the technical qualities of wood ironwood stands high Snow (3) describes it as very strong, hard, heavy, tough, and durable Sargent (2) agrees with him on these points and adds that it is very close grained, compact, susceptible of a beautiful polish, and very durable when in contact with the soil In a list of 429 American woods he ranks it as the seventy-first in fuel value and the seventy-third in specific gravity Record (1) gives it a specific gravity of 0 83, which is as high as that of the better species of hickory

Because of these qualities the wood has a considerable local use for a variety of articles, for example, posts, levers, tool handles, mill cogs, wedges, the axles, tongues, and felloes of wagons, and fuel Investigations of the War Department have disclosed that the wood yields a superior quality of charcoal for use in gas masks

In the matter of resistance to damage from insects and diseases the species likewise ranks high There are no serious insect enemies, and only the older trees are subject to heart rot On the other hand, its thin bark gives it a low fire resistance

* Contribution No 37 from the School of Forestry and Conservation of the University of Michigan

Its chief silvicultural virtues are a high degree of tolerance and of reproductive ability Owing to these characteristics it is able to invade grassy areas in advance of other species and to improve seed-bed conditions to the point of making possible the establishment of reproduction of other species under its protection Hence it may have a value in the future as a nurse tree and as an easily established understory for soil protection in stands of intolerants Another valuable characteristic is its ability to prune itself rapidly and thoroughly in closed stands It is a vigorous sprouter in early life, but little is known of the length of time during which this ability is retained or what may be expected from the sprouts with regard to development

Since the species tends to be most abundant on the better classes of sites and practically absent on the dry sites of the oak-hickory type, one would conclude that its site requirements are at least fairly high Actually there is not much opportunity for accurate checking of this conclusion, because of the prevalence of grazing in the woods of southern Michigan, which causes the failure of reproduction of most of the native species

All the authors who describe the species state that it is a small tree The fact that it is always subordinate and that no individuals ever become dominant, even occasionally, seems to substantiate this statement, which applies to diameter as well as to height

Ironwood is also said to be of slow growth, but this assertion is always made in the form of a flat statement, without any supporting evidence to prove just how slow the growth is or what the causes are Is it due to overhead shading, constriction of crowns due to overstocking, poor site, or some inherent characteristic of the species?

An opportunity to check some of the aspects of its growth was presented in connection with improvement cuttings made in the Eber White woods near Ann Arbor, Michigan In this case any slowness of growth that appeared could not be charged to poor site conditions, since ironwood occurs here in a type containing such species as basswood, yellow poplar, black walnut, and butternut The virtual absence of black oak from this type is probably significant as an indication of a soil moisture condition that is better than average

In the portion of the woods treated ironwood formed a practically complete understory, most of which had resulted from the seeding

activities of a few large individuals scattered through the stand. All the ironwoods occupied a subordinate position in the crown cover and so were subject to a considerable amount of overhead shade. The larger trees were bushy, with full crowns, indicating that they had not suffered from side shading. Most of the smaller trees were crowded and in need of thinning, as shown by short and narrow crowns. Consequently, all the trees studied had had their growth unfavorably affected by either overhead shade or crowding or both. This means that the slow growth indicated by the figures in Tables I and II is not due entirely to the inherent characteristics of the species.

Measurements and age determinations were secured on a total of 1,813 trees. These data were assembled by the usual statistical methods, and balanced curves were then drawn. The figures in the following tables were taken from these curves.

TABLE I

HEIGHT GROWTH

Age in years	Height in feet	Mean periodic in feet
10	11.00	1.10
20	19.50	0.85
30	24.50	0.50
40	28.50	0.40
50	32.50	0.40
60	36.25	0.37
70	39.25	0.30
80	40.60	0.13
90	41.20	0.06
100	41.75	0.05

TABLE II

DIAMETER GROWTH

Age in years	D.B.H. in inches	Mean periodic in inches
10	0.65	0.06
20	1.50	0.08
30	1.90	0.04
40	2.45	0.05
50	3.15	0.07
60	4.20	0.10
70	5.25	0.10
80	6.10	0.08
90	6.70	0.06
100	7.20	0.05

TABLE III

HEIGHT-DIAMETER RELATION

Height in feet	D B H in inches
10	0 60
15	1 20
20	1 55
25	2 00
30	2 85
35	4.00
40	5 55

In a part of the stand in which these earlier measurements were made the ironwood, instead of being eliminated as a weed species, has been given the same treatment as the other species Many trees have been released from overhead shade, and others have been relieved from crowding by thinning The results of this treatment will show more definitely to what extent the slow growth of ironwood is due to its inherent characteristics rather than to overhead shading and constriction of crowns by crowding

UNIVERSITY OF MICHIGAN

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POPULATION REGIONS OF THE SOUTHERN PENINSULA OF MICHIGAN A PRELIMINARY STUDY

STANLEY D DODGE

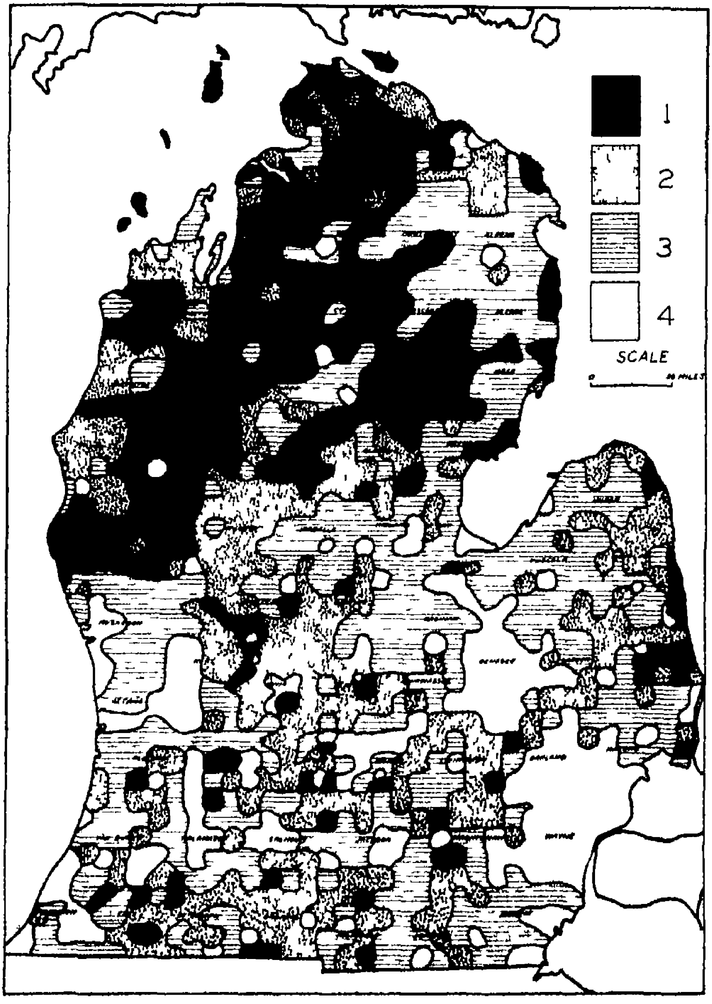
THE distribution of categories of growth and decline of population in the Southern Peninsula of Michigan presents cartographical evidence of what seem to be important considerations in the determination of population regions A similar study of portions of New England reveals the same conditions [1] Apparently the areas of greatest population density are those of continued population growth Where population is sparse, the area generally shows evidence of having been more densely inhabited at some time in the course of its history For the Southern Peninsula of Michigan the peak of population in the townships of the northern counties appears to have coincided with the heyday of timber cutting

The areas of greatest decline (shown in black on Map 3) have embedded in them townships [2] or small groups of townships in which population either has continued to grow or has fallen off less than in the surrounding territory These townships, and especially their central villages, are foci of population attachment in their respective areas They are market centers to which adjacent areas of greater decline are tributary

In the southern counties the areas of greatest decline represent townships from which population has receded toward neighboring areas of maintained or growing numbers of people They are islands, the populating of which has proved unsuccessful in competition with areas of greater fertility or superior market connections

[1] Dodge, S D, "A Study of Population in Vermont and New Hampshire," *Pap Mich Acad Sci, Arts and Letters*, 18 (1932) 131–136 1933 This paper outlines the method employed in determining population categories and presents some of the underlying philosophy on which such determinations may be made

[2] The categories of growth and decline are determined township by township from census reports. The map is generalized In the Northern Peninsula the township areas are so large as to make any generalization meaningless, hence discussion of that large and important area is omitted



MAP 3 Distribution of categories of population growth and decline in Michigan
1, marked decline, 2, partial decline, 3, relatively stable, 4, still growing

Thus from the map of population growth and decline it is possible to lay out tentative population areas, subject to further theoretical testing and practical demonstration in the field[3] Each of these regions has for its center a township which has continued to grow, or, as in the northern counties, one which has declined less than its surrounding territory Each is circumscribed by areas of relatively greater decline which form boundaries between individual regions of more or less continuing prosperity

In the southeastern part of the state the whole of Wayne County and parts of Washtenaw, Oakland, and McComb counties have continued to grow, the townships in which increasing population is noticed are tributary to, and to a certain extent dependent on, the metropolitan Detroit center The larger part of Genesee County, with a neck stretching northwestward through Saginaw County to the city of Saginaw, an area closely linked with Detroit, industrially and by thoroughfares, has also maintained its population in a growing state

West of Detroit, centers have continued to grow in Jackson, Calhoun, Kalamazoo, and Van Buren counties, at Jackson, Battle Creek, Kalamazoo, and Paw Paw, respectively These centers follow the main line and branches of the Michigan Central Railroad, the principal through route from east to west in the southern part of the state[4] A string of minor centers of growth lies in the southernmost tier of counties, at prominent market points, such as Hillsdale, where two minor branches of the main through railroads cross[5] Most of these centers, especially along the main line of the Michigan Central Railroad, are connected with one another by areas in which population has been maintained at or near a peak, although here and there areas of partial or marked decline intervene, especially in the tiers of counties just north and south of that through which the railroad runs

In the central part of the state, west of Saginaw, the areas of

[3] For example, by the methods outlined in S D Dodge, "Bureau and the Princeton Community," *Ann Assn Am Geog*, 22 159-209 1932 The applicability of this method seems probable in portions of the Vermont-New Hampshire area, see footnote 1

[4] The Paw Paw area is centered on the branch line from Lawton to Benton Harbor

[5] The second through east-west railroad is the New York Central which runs through the northern parts of Ohio and Indiana from Toledo to Elkhart Branches run north at intervals into the state of Michigan

partial decline become more continuous and the areas of growth fewer and smaller, except around Grand Rapids, which is connected by areas of increasing population with Kalamazoo to the south

In the northern part of the state large areas have suffered continuous decline since the peak of population growth in the latter decades of the nineteenth century The northeastern part of the state, with Alpena County apparently at the focus, seems to have suffered less than the rest But even here areas of marked and partial decline come in to indicate failing prosperity Throughout the large area of marked diminution of population numbers there are centers of relatively less decline or even of continued growth These represent the centers from which the remaining exploitation of the northern area is being carried on, though the economic base for their continued existence is small and precarious

The map of the distribution of categories of population growth and decline merits detailed study, for it appears to reveal those essential groupings of people which are the fundamental units in the use of the land The linkages of the various groups to the larger centers within and without the state by roads, by railroads, by lake, and by other means of travel should reveal the geographical pattern of the economic development, the only real pattern for understanding the significance of the land in the life of the people of the State of Michigan

University of Michigan

A SPECIALIZED RICE DISTRICT IN THE MIDDLE PARAHYBA VALLEY OF BRAZIL *

PRESTON E JAMES

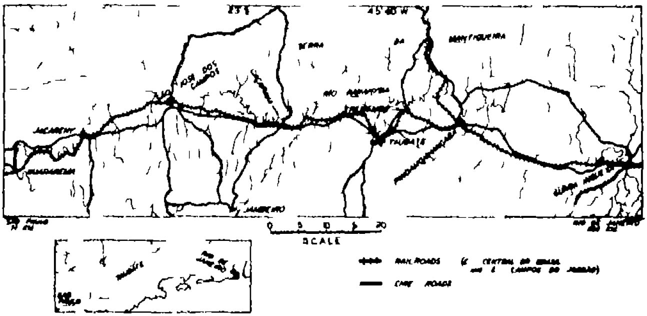
RICE is an important sustenance crop in southeastern Brazil A staple food combination of the Brazilian people is the very palatable mixture of rice and black beans From Rio Grande do Sul northward rice is produced as a part of the prevailing crop combination of "maize, rice, and beans" Although some upland or dry field rice is grown, especially in the new coffee lands of São Paulo, most of the supply comes from paddies

The climatic conditions of southeastern Brazil are quite favorable for rice The domestication of this plant is supposed to have taken place in the rainy subtropical margins of southeastern Asia, and today the monsoon lands are by far the most important rice-producing regions of the world Although the heavy monsoon rains, so important for the best yields in the Orient, are lacking in Brazil, nevertheless the climatic conditions on the eastern margins of all the continents in higher low latitudes and lower middle latitudes (on the borderlands between the A and C climates) are well suited to this crop Rice might be expected to occupy an important position among the cereals in this sector of the general climatic pattern of the world

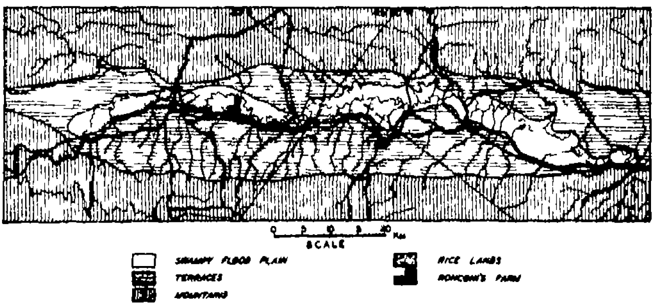
A closer examination of the Brazilian rice lands, however, reveals some striking contrasts with those of the Orient Because rice requires a very special set of surface, soil, and moisture conditions, there is a marked tendency to use the suitable lands exclusively or dominantly for this one crop From the Orient have come many descriptions of the intensive nature of the occupance the dense populations, in some places amounting to thousands of people per

* The field work on which this paper is based was supported in part by grants-in-aid from the National Research Council and the University of Michigan The study of the Parahyba Valley was made in October, 1930

square mile, the minute sculpturing of man-made landforms, even on hilly surfaces of considerable slope, the careful control of water through systems of irrigation and drainage, so that the inundation and drying of the paddies may be carried out at the will of the



MAP 4 Place names of the Middle Parahyba Valley



MAP 5. Surface configuration and rice distribution of the Middle Parahyba Valley

cultivators, and the persistent application of human labor to minute fields at all stages of the cycle from the preparation of the soil to the harvesting of the crop[1] But how very different are the practices in Brazil! In contrast to the Orient there are scanty populations,

[1] Hall R B, "The Yamato Basin, Japan,' *Ann. Assn Am Geog*, 22 211–230 1932

only those parts of the surface which are naturally suited to rice are so used, dikes and drainage ditches are at a minimum, and for inundation the cultivators depend on the natural and uncontrolled floods of the rivers Here we have an example of the effect of cultural heritage in directing the occupance of land

One of the most important of the areas of specialized rice production in Brazil is located in the Middle Parahyba Valley, between São Paulo city and Rio de Janeiro Rice fields are visible along the railroad which connects these cities, between the towns of Tremembe and Jacarehy (Map 4) A closer inspection of this district reveals many of the characteristic features of Brazilian occupance as a whole, and brings forth in a striking way the many contrasts with the Oriental rice lands

THE LAND

The Middle Parahyba, from its big bend a little upstream from Jacarehy northeastward to Entre Rios, north of Rio de Janeiro, flows through a deep and broad valley between massive ranges of mountains On its northern side it is dominated by the cloud-capped bulk of the Serra da Mantiqueira [3] Passage across the valley or its bordering mountains is difficult, and although the Middle Parahyba offers an admirable highway, access to it at either end — above Jacarehy or below Entre Rios — is difficult

The bottom of the valley is complex It is composed of a series of rock basins, separated by rock sills and lined by terraces Supported on each of the rock sills the terraces extend toward the center of the lowlands, confining the channel of the river between steep banks Upstream from each constriction, however, the flood plain widens, and the river meanders across broad, flat, swampy areas (Map 5) In most years the flood waters cover these swamps, but during the dry season the Parahyba lies some four to nine meters below the general level of the flood plain The soils on these low-lying parts of the valley are composed of black muck, mixed with a considerable amount of clay The surface meter or so is fairly compact, but springy, underneath is a soft, wet muck

The flood plain terminates sharply against the front of the

[3] James, P E, "The Coffee Lands of Southeastern Brazil," *Geog Rev*, 22 225-244. 1932 See Figure 3 for a map of the surface configuration of south eastern Brazil.

terraces, which rise some twenty meters above the swamps (Pl LXVI, Fig 1) Short streams have dissected these terraces to a maturity of rounded hills and narrow flat-bottomed valleys The red clay soils of the terraces are in marked contrast to the black mucks of the flood plain

The area was probably originally forested, perhaps with some swampy savannas on parts of the lower lands[3] On the climatic pattern it is located near the equatorward margin of the mild winter lands, having distinct high-sun (January) rains, and low-sun (July) droughts (border line between Cw and Aw of the Köppen system)

THE COURSE OF SETTLEMENT

The *fazendas* of the Middle Parahyba are among the oldest in the interior of southeastern Brazil The road from Rio de Janeiro to São Paulo and thence to southern Brazil followed, and still follows, the terrace on the southern side of this valley Along this road the first important area of coffee production developed late in the eighteenth century[4] The coffee trees, the pastures, and the lesser areas devoted to sustenance crops were all located on the terraces, the swampy flood plains were left untouched

Although the main line of travel followed the southern side of the valley, a number of settlements were established on the northern side Communications across the valley became important Since the swampy areas were practically impassable, these trans-valley roads were established at the narrow places, and small commercial towns grew up along the main road on the southern terrace at each point where passage across the valley to the northern side was thus relatively easy This relationship is well illustrated on Map 5

The distribution of coffee, however, was related only to the gross features of the terrain, and the coffee economy remained speculative and extensive After fifty or seventy-five years the decrease of yield on the poorly cultivated plantations, together with the increasing competition from the rich new coffee lands of western São Paulo state, resulted in the gradual abandonment of many of the Parahyba plantations. The coffee trees, neglected, turned brown and decayed By 1920 most of the former fazendas were utilized for pasture, and the towns were only decadent rem-

[3] Maull, O, *Vom Itatiaya zum Paraguay* (Leipzig, 1930), p 171 *et passim*.

[4] James *op cit*, Fig 1

nants of this former prosperity The land was exhausted, and the bulk of the population had moved on to new areas

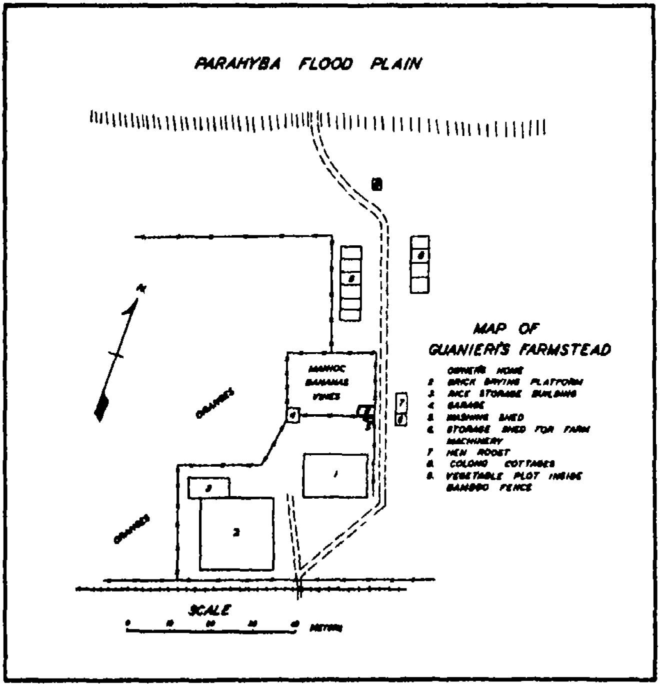
Rice is not a new crop in this valley It was grown as a sustenance crop along with maize and beans, occupying the bottoms of the mature tributaries which dissect the terraces Some of the rice perhaps was dry rice, interplanted with young coffee, as is the present practice in western São Paulo About 1900, however, some of the flood plain lands near Taubate were cleared and planted to rice The yields were excellent, yet no sudden increase of land so used took place

The present rice district is the result of a boom during the post-war period (1918–20), which only repeated what had previously taken place in coffee From the few scattered fields near Taubate the area under rice extended rapidly until now it stretches from Tremembe to Jacarehy (stippled area on Map 5) A typical experience is related by Sr Guarnieri About 1918 he bought twelve square kilometers of land between Caçapava and São Jose dos Campos, paying four contos for it Just before the present decline in values he was offered for this same land two hundred contos [5] With the aid of this "unearned increment" he is enabled to live in São Paulo, while a part of his estate is being occupied by a son-in-law and another part is rented to tenants Fortunes made in this way, and perhaps lost with equal facility, do not encourage close attachment to the land The Guarnieri farmstead, a typical layout, is presented as Map 6

When one examines these rice lands in greater detail, a number of characteristic features may be discerned The distribution of rice is found to be governed primarily by accessibility to the lines of communication — lines which were not established in their present positions for the service of the rice district Thus rice is grown only on the flood plain south of the river, where it is easily accessible to the railroad, which follows the southern terrace The distribution of rice on this southern half of the flood plain represents an adjustment, again, only to the gross features of the physical setting The fact that there are some parts of the flood plain more suited and some less suited to crops is disregarded Some places are too dry, others too soft, so that the use of machinery or even of oxen is diffi-

[5] Considering the decline in the value of the conto, this represents a gain approximately from $1,100 to $20,000

cult, other places are too wet and cannot easily be drained of the flood waters Yet, with the exception of the immediate back marsh along the base of the terrace, all the most accessible sites have been utilized for rice regardless of these details of physical suitability The rice lands form a belt or zone, about a kilometer or a kilometer



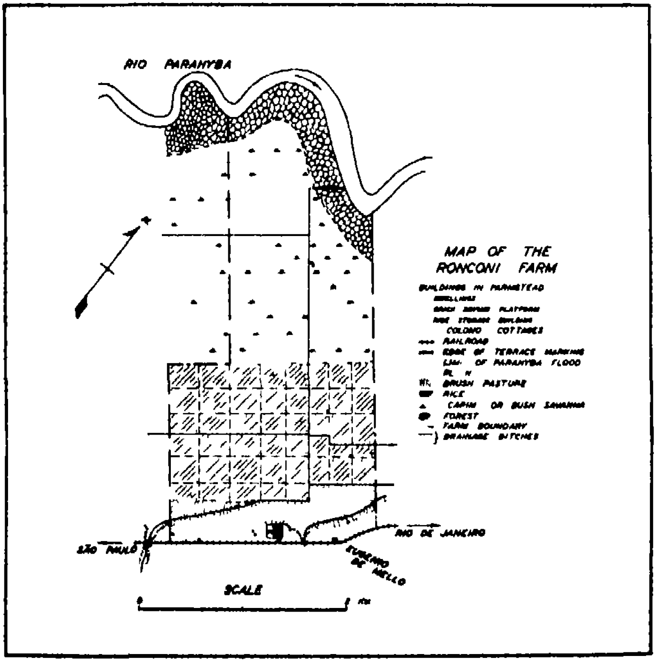
MAP 6

and a half in width, which follows the outer margin of the flood plain, leaving only a narrow belt of back marsh as brush pasture immediately adjacent to the terrace There is still considerable unused area of flood plain between the present margin of the rice lands and the Parahyba River, and further increase of production will be brought about by extending the area in this direction At no place

are the characteristic crescentic patterns, based on the physical features of a river flood plain, brought out in the occupance patterns of this district, as we may expect them to be brought out in more advanced stages of settlement

A STUDY OF AN OCCUPANCE UNIT

A more intimate glimpse of the characteristics of the occupance units may be had by a study of Sr Ronconi's farm (Map 7) Sr



MAP 7

Ronconi, like most of the farmers in the rice district, is a tenant He occupies a portion of the estate of Sr Guarnieri Ronconi's father owns a large estate near Taubate, but his several sons work other pieces of land as tenants in various parts of the valley The farm

in question is let on a six-year lease, and consists of about six hundred hectares[6] The property extends from the railroad on the southern terrace northwestward about four kilometers to the river The farm buildings (Pl LXVI, Fig 2), which include a brick drying platform, a rice storehouse or *deposito,* and the farmer's home, are located on the terrace near the railroad station of Eugenio de Mello All along the terrace edge, mostly between the railroad and the sharp drop to the flood plain, are the scattered, irregularly placed mud-and-wattle huts of the *colonos* or tenant laborers (Pl LXVII, Fig 1) — for in this area there are tenant laborers on tenant farms Sr Ronconi hires one hundred and ten people[7] — men, women, and children belonging to thirty-four families Most of these are new Italian immigrants Obviously their abode on any one farm, or even in the rice district, is a very temporary affair

Rice is planted on about a third of the total area of the farm (Map 7) Immediately at the base of the terrace bluff, as we have said, the poorly drained back marsh, into which flows a tributary stream from the terrace, is left in brush pasture for the oxen Beyond this are the square rice fields, separated by a rectangular pattern of shallow ditches (Pl LXVII, Fig 2), with a few master ditches which run from estate to estate and carry off the flood waters, or the waters of smaller tributaries from the terrace Farther out on the plain is a bush savanna, not yet cleared for rice, and at the present time used for nothing Still farther out near the main stream there is the usual fringe of woodland The inhabitants on the completely deforested terrace find this belt of woodland the nearest source of firewood, and carry their bundles of sticks laboriously across four kilometers of stifling hot savanna and ditch-lined rice fields

Certain of the farm practices carried on here reveal the extensive character of the economy and throw additional light on the occupance In the first place the rice crop depends entirely for its flooding on the natural rise of the Parahyba River No irrigation works or flood control system of any kind have been developed, other than the simple ditches which run from estate to estate In fact, the chief agricultural problem of the area is the inadequacy of the

[6] About 1,482 acres.

[7] To whom he paid in 1930 an average daily wage of three milreis (about 30 cents)

water supply, not the superabundance of it But in wet years there is enough water to bring fair yields [8]

Farm activities are, of course, timed by the rhythm of the seasons During the dry season (June to September) the weeds are cut and burned, or new lands are burned over and cleared August to November is the plowing season Shallow plows are most commonly drawn by oxen (Pl LXVIII), in a few cases by tractors, but where the land is so soft and wet that oxen or tractors may break through, the plows are drawn by gangs of men The rice is sown in rows, forty centimeters apart, from September to November, after which there must be at least three cleanings to keep down the weeds If the land could be flooded at this time the weeds could easily be controlled, but the floods usually do not arrive until later When the water does rise and cover the growing rice, it remains on the land too long, and the harvest in March, April, and May is generally carried on from fields knee-deep in water By the end of the harvest season the floods have entirely receded, and a profusion of weeds springs up

On the Ronconi farm, as elsewhere in this area, the one important crop is rice There seems to be little difficulty in the marketing of it, especially since this district is strategically located so that it can take advantage of prices at both Rio de Janeiro and São Paulo [9] There are almost no other crops grown On the terraces, to be sure, on some of the other farms, there are small impromptu fields of sustenance crops, a few groves of oranges (Map 6), and a little area still in coffee Most of the area of the terrace lands is devoted to cattle pasture But these are subordinate items in a highly specialised crop district

CONCLUSION

This little sketch touches one of the keynotes in the geography of southeastern Brazil Even in an area of specialised crop production, more or less favorably situated in terms of the natural equipment of the area and access to markets, the occupance is loosely

[8] From farmers' estimates the average yield in the valley seems to range between 40 and 80 bags (of 60 kilograms each) per hectare Translated into pounds per acre the range is from about 500 lb to just under 1000 lb — not very large yields as compared with those of other rice areas of the world

[9] James, P E, "Rio de Janeiro and São Paulo," *Geog Rev*, 23 271-298. 1933.

organized, and only vaguely localized on the land There is none of that intimate attachment and adjustment to the varying qualities of the surface and soils which is characteristic of such densely populated areas as the Oriental rice lands Whether this district represents the outline of a pattern of occupance which in the course of time will crystallize into more permanent form, or whether, like that of the coffee which preceded it, the present occupance will in time decline and disappear is not at present predictable

University of Michigan

PLATE LXVI

FIG. 1. Ronconi's farmstead on the edge of the terrace. View taken from the flood plain looking southeast.

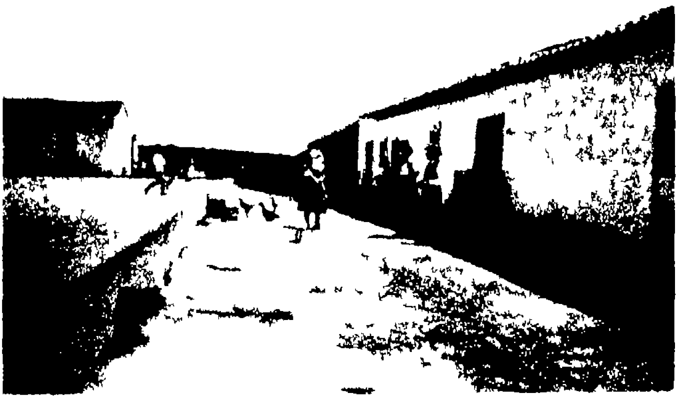


FIG. 2. Dwellings of the Ronconi farm arranged facing the brick drying platform. Compare Map 7.

PLATE LXVII

1. A new and an old *colono* hut on the terrace. View looking across the railroad to the rice lands. In the background, on the northwestern side of the valley, is the massive bulk of the Serra da Mantiqueira.

FIG. 2. Drainage ditch in newly plowed rice lands. In the background is the terrace on the southwestern side of the valley.

PLATE LXVIII

Farming activities on the rice lands: in the foreground rice being planted; in the background oxen plowing and harrowing a field. The oxen are knee-deep in the soft ground. View looking toward the terrace on the southeastern side of the valley.

CLASSIFICATION OF LAND ON A GEOGRAPHIC BASIS *

JETHRO OTTO VEATCH

GEOGRAPHY is the science of areal differentiation It is concerned with the earth as the differentiated home of man The geographer must, therefore, have as a basis for his science a classification of natural environment This is tantamount to stating that he must have a classification of the features of the earth's surface The most obvious division of the earth's surface is the separation into water areas (seas) and land areas For the further division of the land areas it would appear that climate might be the logical criterion, since climate determines in a broad way the kind of life, plant and animal, which can exist However, the classification of climate has not been perfected to the degree that the equivalent climatic expression for the smaller units of land can be stated The logical recourse is to classify the forms, or physiognomy, of the land Man at some stage in his development must have dimly recognized the fact that some parts of the earth were flat, others rough and broken, but later he learned that such a simple division was not sufficient, and gradually invented terms to designate differences in aspect, such as plains, plateaus, hills, mountains, valleys, basins, lakes, swamps, and streams The grouping of forms of the earth's surface in an orderly fashion on the basis of their origin constitutes physiography The physiographic divisions and topographic forms have served as a proper basis for the geographer's correlations, since the kind of surface has affected the numbers and movements of human beings But two other factors enter which are not everywhere implied in the physiographic, or surface, divisions These two factors are soil and vegetation The soil, after all, is perhaps the most important environmental factor, since directly or indirectly it is the source of civilized man's food and clothing, whereas the

* Authorized as Journal Article No 155 (N S) from the Michigan Agricultural Experiment Station

amount of arable land and the kind and productivity of the soil determine the population, or if not everywhere the number of people, indirectly the kind of industry and commerce and to some extent the mental traits and type of social organization

In effect, what is here proposed is to add the factor of soil to the physiographic, or surface, division, in the mapping of land types and to recognize associations of minor topographic forms as a basis of differentiation of minor land types A combination of recognized physiographic divisions might have to be made for the broader land types, or those of the first and second order, but for the land types of the smaller orders the recognized physiographic divisions would have to be subdivided, although in a few cases it might happen that some recognized physiographic division is also a unit in soil and vegetation To add the factor of soil is not so simple as it might appear, since there immediately arises the question of what characteristic or peculiarity of soil is to be selected as most important in the differentiation of land types For the broader regions the family characteristics of soils would be selected, for the smaller physiographic or topographic divisions, the textural class would probably be selected as most important generally, but other soil classes might be selected according to their importance in relation to plant growth and use of land in the particular area being mapped, whether a physical condition, a chemical character, or a moisture condition Where soils are quite variable, or where there are several kinds occurring in small separate bodies, peculiar associations of them would have to be recognized and contrasted with one another To carry out the mapping of land to the smallest units of the taxonomic scheme, detailed maps of plant associations of natural vegetation would be desiderata

In the land-classification scheme beginning with the broadest divisions the order would be (1) zones, which are climatic, (2) divisions of these zones, which are units in soil and vegetation, as, for example, the grass land, dark-colored soil region, in contrast to the gray soils, forested land region of the North Temperate Zone, (3) divisions which are physiographic in nature, that is, the major physiographic divisions lying within the boundaries of (2), (4) the units of the separate relief features of (3) grouped according to sameness in soil and vegetation, (5) subdivision of the relief features of (4) on the basis of differences in soils and vegetation At

this point the "land divisions" would probably in a great many instances be practically equivalent to the "soil types" as at present *differentiated in the detailed, or inch-to-the-mile mapping by the* Soil Survey Division of the U S Bureau of Chemistry and Soils

If land mapping were to be carried on in organized manner, the need for naming and correlating the divisions would at once arise From the nature of things no rigid, mathematical rules of procedure for differentiation and correlation can be set down, any more than they can be set down for the classification of geological formations, physiographic divisions, or associations of natural vegetation The principle to be followed is All land areas having the same topographic expression together with the same associations of soil and natural vegetation should be given the same geographic name

The Land Economic Survey Division of the Department of Conservation, State of Michigan, has been constructing maps of the "natural land divisions" in the separate counties of the state which it has mapped in detail These divisions have a great deal of local geographic significance, but no attempt has been made to correlate *the areas so that the state-wide geographic significance of any par*ticular land division can be determined The difficulties in the way of correlation are not insurmountable The divisions are primarily physiographic or topographic and are related to the divisions of the geological map of the formations and features of glacial origin, such as moraines, till plains, and outwash plains These separate glacial features and formations, however, are not sufficiently uniform in topography, vegetation, and soils to constitute within themselves a land entity from a geographic point of view, or to represent the same land types throughout the whole state The problem in correlation is, then, to determine whether separate bodies of land possess sameness in associations of topographic forms, and associations of soils and vegetation

The original native vegetation, of course, cannot everywhere be employed as one of the criteria, since there may be some localities where it has been completely destroyed or altered by man

An illustration of the procedure in the recognition of land types and their correlation is given A certain area in central Michigan is hilly and as a whole is a bold relief feature in contrast to the associated lower plains of sand and clay Slopes are smooth and rounded, rather than steep and eroded, and generally are not in excess of

15 per cent The included valleys, or basins, appear to be partly filled with sand, have flattish floors, and may not be occupied by streams, though present, streams, lakes, and swamps are not distinguishing features The local differences in altitude do not exceed 100 or 150 feet The soil is prevailingly a deep, dry sand, low in fertility, with an association of small patches of gravelly and clayey soil The original forest cover was dominated by Norway (red) pine The second growth is dominated by oaks Wherever this same type of constructional topography, deep sand soil, and pine-oak cover occurs the same land-type name will be applied But should there be any notable increase in the proportion of clay and loam soils, in the amount and distribution of swamps and lakes, or a replacement of pine by hardwoods, these things would be regarded as a sufficient basis for establishing a new land type, of the same order as the first, and for drawing a boundary line on the land map

The pedographic land division constitutes a more logical unit for geographic studies than does the political unit, since the boundaries of the latter may be quite contrary to natural boundaries But where it is not practicable to adopt the natural unit, statistics or other data are more understandable when the proportional area and location of different land types in the governmental unit are known In a geographic study of a region the pedographic map and the economic map (divisions based primarily upon type of industry and upon population) are supplementary to each other

A tentative key for Michigan is presented here for the purpose of illustrating further the idea of the geographic land classification

Key to Land Types of Michigan

NORTH TEMPERATE LAND ZONE

Great Lakes Plains Region (physiographic-pedologic)

(Parent soil material unconsolidated glacial deposits)

I Podsol-forest land divison (northern part of state)
- A Dry sandy gravelly forested plains (major type)
  - 1 Pine plains type
    - *a*) Norway pine — jack pine plains (Grayling subtype)
    - *b*) White pine plains (more loamy and gravelly soil — Stambaugh subtype)
  - 2 Hardwood plains type
    - *a*) Kalkaska subtype (more limy soils)
    - *b*) Au Train subtype (less productive, acid hardpan soils)

- B Diversified wet and dry sandy forested plains
  - 1 Sand and peat swamp type (mainly coniferous)
  - 2 Sand and peat swamp type (mixed hardwoods and conifers, more productive clay soils associated)
- C Hilly sandy land (diversified topography soils and vegetation)
  - 1 Pine land, deep dry sand (few lakes streams or swamps)
  - 2 Hardwood hills, deep sands lakes, and swamps associated)
  - 3 Hardwood hills heavier soils and more stony land
- D Sandy plateau upland and bench land
  - 1 Hardwood plateaus (intersected by deep valleys)
    - a) Sandy table-land (steep escarpments and valley slopes)
    - b) High stream-cut bench land (Munising subtype)
  - 2 Level and gently rolling sandy highland (lakes, swamps shallow depressions)
- E Lake bed clay plains (few or no lakes, generally not stony)
  - 1 Low lying clay-swamp plains (Chippewa subtype)
  - 2 High, stream-cut clay plains (Ontonagon subtype)
- F Rolling stony, clay plains (lakes and swamps)
  - 1 Clay ridge type (oval or parallel ridges, sandy and swampy valleys associated)
    - a) Hardwood ridges (more limy soils)
    - b) Hardwood and conifer ridges (high altitude very stony, Iron County type)
  - 2 Rolling clay plains (large proportion of wet land associated)
  - 3 Stony, clay land – swamp type
    - a) Stony loam, hardwood–conifer land (rock outcrop wet mineral soil and muskeg swamp associated – Gogebic subtype)
    - b) Limy soils (Trenary-Onaway subtype)
- G Stony, bedrock plains and plateaus
  - 1 Limestone bedrock type
  - 2 Sandstone bedrock type
  - 3 Crystalline bedrock type
- H Superior highland mountainous plateau and rock knob land
  - 1 Huron Mountains type
  - 2 Copper Range rock-knob type
  - 3 Negaunee rock-knob type
- I Swamp-plain type
  - 1 Spruce–cedar swamp, small bodies of wet and dry sands associated
  - 2 Swamp with islands of loam and clay soils associated
- J Dune type
- K Water (larger water-covered areas)

II Brown forest-soil land division (southern part of state)

- A Dry, sandy gravelly plains (major type)
  - 1 Oak–hickory land (more clayey and more productive soils)
    - a) Smooth plain subtype
    - b) Deeply pitted, lake-swamp subtype
  - 2 Pine–oak land (deeper sands and less productive soils)
    - a) Southern oak–hickory sandy land
    - b) Northern pine–oak sandy land
    - c) White pine–hardwood land (gravelly and more loamy soils)

3 Prairie land (only a few areas of sufficient size to constitute separate land types)

B Diversified wet and dry sandy plains (few or no lakes and streams)
1 Intermixed wet and dry sands (sandier and less fertile soils)
2 Intermixed wet and dry sands (large proportion of clay and the more fertile wet sandy soils of the Wauseon-Gilford types)

C Hilly sandy land (basins, knobs, lakes, swamps, few streams)
1 Pine and mixed hardwood subtype (dominantly deeper sand)
2 Oak–hickory and maple–beech subtype (higher proportion of sandy loam and loam soils)
3 White pine–hardwood land (higher proportion of sandy loam)

D Level lake-bed clay plains land (more fertile soils, hardwood forest)
1 Darker wet clay land (muck land associated, no lakes, few streams, not stony)
2 High clay land (partly stony, more deeply trenched by streams)

E Rolling clay plains land
1 More level land (few or no lakes and streams, swales and plats of dark-colored soil, small proportion of muck land)
2 Rolling land (large proportion of muck and other swampy land in net form or in widely distributed shallow basins)
3 More strongly sloping land (stream dissection, very small proportion of swamp)

F Dune land

G Muck swamp land (only a few areas of sufficient size to constitute a separate land type)

As an illustration of how the major land types of the state may be subdivided into a great number of smaller units, the dry, sandy, gravelly plains (II A) of the southern part of the state are selected

DRY, SANDY, GRAVELLY PLAINS (MAJOR LAND TYPE)

Oak–hickory and other hardwood land (Fox type of soil comprises 50 per cent or more of the area)

I Smooth highland (relatively few streams, lakes, and swamps)
A Heavier soils (maple beech, oaks, walnut, elm, etc)
B Sandy soils (oaks or oak–hickory)

II Pitted and diversified plains (lakes and swamps numerous)
A Heavier soils (mainly loams)
1 Cobbly and gravelly soils
2 Soils free from stones
B Lighter soils (mainly sandy loams and sands)
1 Level land
2 Basin slopes
C Dark soils (maple, beech, elm, walnut, oaks, etc)

III Valley plains
A Chains of lakes and swamps
1 Deep sand soils associated
2. Wet clay soils associated

- B Terrace plains bordering rivers (few or no lakes)
  - 1 Loamy and darker soils
  - 2 Lighter and sandier soils
- IV Dissected terrace plains and escarpments (no lakes or swamps)
  - A Slopes with moist and dark soils at the base
  - B Slopes with dry sandy and gravelly wash at the base

Subdivision may be carried even farther than has been done here, although there may be no practicable need for such refinement The particular unit selected for mapping will depend upon the scale of the base map used and the purpose in mind

Michigan State College
East Lansing, Michigan

EBEN: A FINNISH COMMUNITY IN THE UPPER PENINSULA OF MICHIGAN

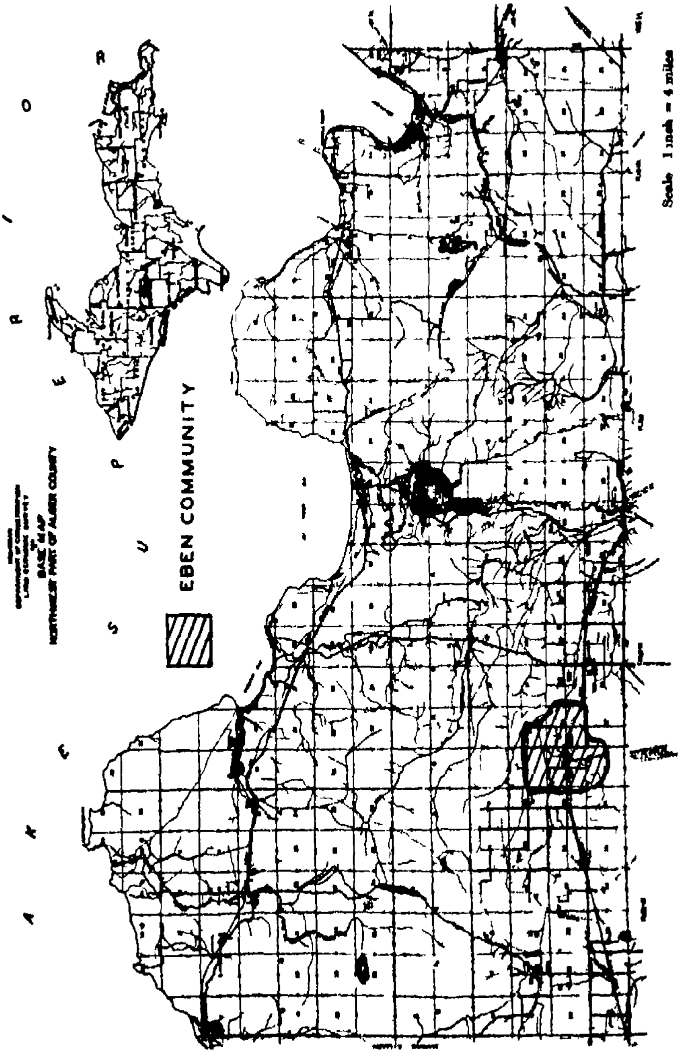
LEONARD S. WILSON

THE village and umland of Eben, which is located in Alger County about twenty miles west-southwest of Munising in the Upper Peninsula of Michigan (Map 8), constitute a Finnish community. The pioneer settler of the district places the date of founding as the spring of 1902. At that time the mines around Calumet had closed, and the Finns who had been induced to move from the home land on the assumption that wages paid in the United States were higher than the income which could be derived from farming in Finland were forced to return to the agricultural practices which they had abandoned upon emigrating. The similarity of climate, land surface, and vegetation to those of Finland caused them to be readily persuaded by land speculators to purchase tracts which would not be considered suitable agricultural land by immigrants from other countries. It is said, locally, that if a Finn is given his choice between a well-drained, cleared, first-quality farm, and a piece of poorly drained, rocky, cut-over land, he will choose the latter. It is on this poor marginal type of land that the Finnish community of Eben is located.

OLD AND NEW FINLAND

The climate of Eben is not conducive to the practice of agriculture except by a people who have had long experience in a similar environment. The short growing season averages only seventy-seven days, and in some years it is considerably less. This limits agricultural production to hay, the more hardy grains, and root crops. These are essentially cattle feed, and as a result domestic animals play a most important part in the economy of the region.

Both Eben and the city of Helsingfors in southern Finland are located in Köppen's Dfb climatic division. The accompanying tables show some striking similarities between Chatham, Michigan, the nearest station to Eben, and the capital city of Finland.



Map 8. Location of the community of Eben

CHATHAM, MICHIGAN (average from 1900 to 1930)[1]

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp	14 1	13 8	23 6	36 4	48	58 2	63 2	61 3	54 6	44 4	32	19
Rf	2 43	1 9	1 7	1 8	3 3	3 0	3 5	3 1	4 4	2 8	3	2 8

Average for the year at Chatham Temp 39 2, Rf 34.20

HELSINGFORS, FINLAND (average from 1886 to 1915)[2]

	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Temp	22	21	29	35	46	55	62	58	51	42	32	25
Rf	1 9	1 9	1 8	1 6	1 7	1 8	2 1	3 1	6 0	2 3	2 6	6 2

Average for the year at Helsingfors Temp 40 0, Rf 24 8

These data show a broad similarity between the two stations The differences are primarily due to the marine influence of the Baltic Sea on Helsingfors The average date of the last killing frost in the Eben district is June 10, that of the first frost severe enough to kill is September 15 The average rainfall during the growing season is usually about 12 inches The average temperature during the same period is between 56 and 58 degrees F, the minimum is 46 degrees and the maximum is 70 degrees The average hours of sunshine during the growing season as based on the nearest station, which is Sault Ste Marie, shows the following distribution

POSSIBLE HOURS OF SUNSHINE[3]

Months	May	June	July	August	Total
Hours	461 8	468 6	474 3	440 4	1 845 1

Professor J O Veatch has placed the Eben district in the "Trenary Hardwood Plains" division[4] By definition this would mean that the surface soil is of a brown loamy variety and is underlain by clayey subsoils It is in large part stony and rests on a limestone bedrock In relief, the highland is rolling to level, with low ridges and a large portion of swamp land The area has been completely glaciated

A large part of the surface of Finland is occupied by rivers, lakes,

[1] Material supplied by D A Seeley, state meteorologist, East Lansing

[2] Birkeland, B J and Föyn, N J, *Klima von Nordwesteuropa* , *Handbuch der Klimatologie* (Berlin, 1932), Vol 3, Part 50, p 79

[3] Putnam, G W, *Successful Farm Practices in the Upper Peninsula, Special Bulletin No 215*, Michigan State College (East Lansing, 1931), pp 1–69

[4] Veatch, Jethro O, "Natural Geographic Divisions of Land," *Pap Mich. Acad. Sci, Arts and Letters* 14 (1930) 417–432 1931

and marshes[5] The name "Finland" means "swamp land" It, *too*, has been glaciated Except for a few outcroppings of the bedrock, the surface is composed entirely of drift material, with a considerable number of boulders included The vegetation of Finland and of the Eben area is similar Pine, spruce, birch, and aspen are indigenous to both, as is tamarack in the swamps

Between 80 and 90 per cent of the people of Finland are engaged in agriculture, the principal crops are hay, oats, and barley[6] The number of important industries in Finland, as might be expected, is small Wood and wood products are the only ones of importance Eben community differs only in the fact that the timber resources have been exploited until so little remains that it is of no commercial significance The Finns have introduced into the area many peculiarities of agricultural practice, cultural heritage, and economic development

The Lineaments of the Area

The boundaries of the Eben community were determined entirely on an economic basis (Map 9) Post-office lists, inquiries about the trading limits of the three stores in the village, and personal interviews were the methods employed to secure data for this part of the study The road-turning method proved to be satisfactory in determining the limits in a reconnaissance study and was substantiated by the methods previously mentioned[7] The northwestern limit of the area was found to correspond with the Algonquin Lake level Beyond this boundary the land falls off rapidly and becomes swampy It is entirely unsuited to farming The northern and western limits also coincided with features of the natural landscape, as well as with the slash cover which remained after the logging operations had been concluded No natural limits were found to determine the boundary on the remaining borders Within these limits lies the community of Eben, similar throughout in landscape, cultural heritage, and development

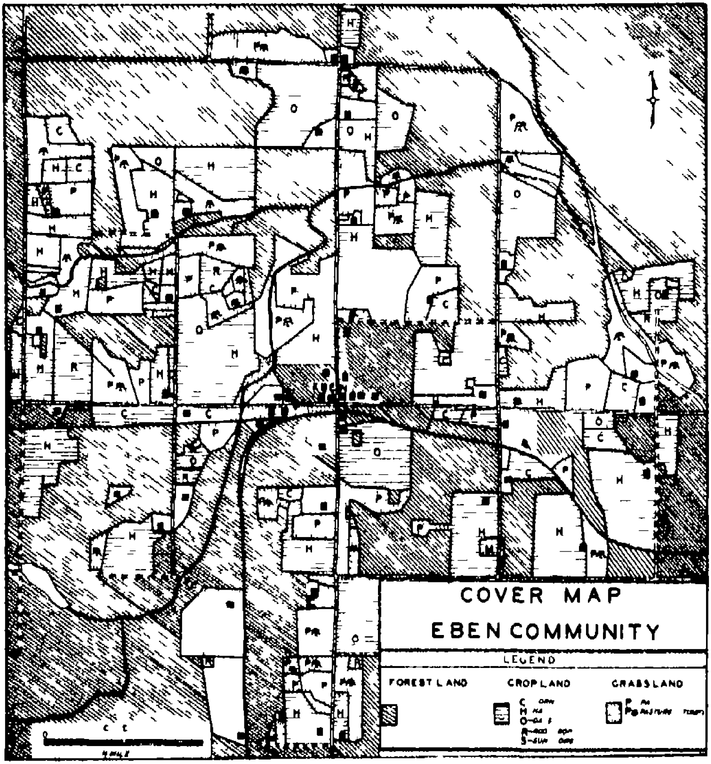
The Cover Map and Regional Economy

The outstanding features of the cover map (Map 9) are the confused field boundaries along the roads and the predominance of

[5] Van Cleef, Eugene, 'The Finn in America," *Geog Rev*, 6 184–214 1918

[6] *Ibid*, pp 184–214

[7] For a discussion of road turnings see Stanley D Dodge, "Bureau and the Princeton Community," *Ann. Assn Am Geog*, 22 158–209 1932



MAP 9

fodder crops almost to the exclusion of all others The former condition is in part caused by the frontier-like nature of the community When the Finn settled on the land he had to remove not only the second-growth vegetation but also the large stumps which remained after logging (Pl LXIX, Fig 2) The practice has been to clear a small plot the first year in order to plant it in the following spring At a later date, when more land has been cleared, this may become a barnyard pasture The stumps from the cleared land are

stacked at the margins of the field and are used as fences This method of clearing a small area when needed has resulted in an irregular and complex pattern of fields bordering the roads. The centers of the areas bounded by the right-angled road pattern have not been entirely cleared, and they serve the owners as wood lots

The second condition, the predominance of crops essentially for cattle consumption, is largely caused by the preference of the Finns for a diet almost entirely of meat Another conditioning element is the climate of the district, which favors crops which are best suited for forage

Settlement Forms

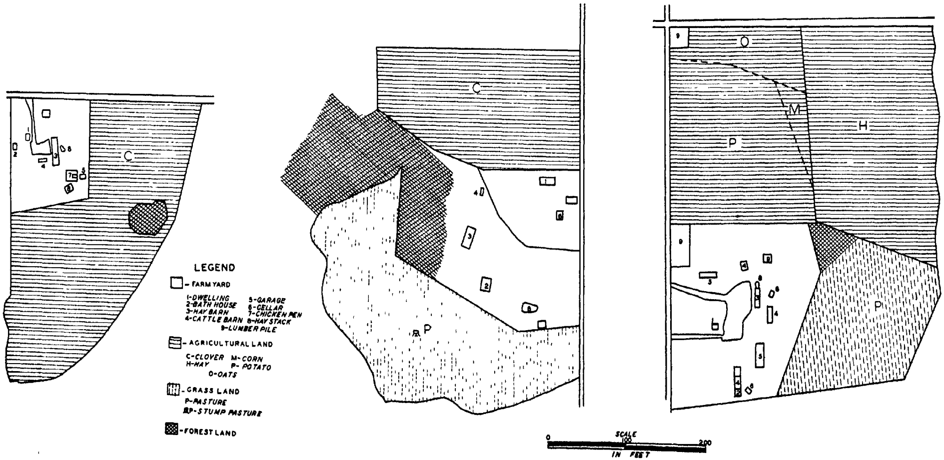
The practice of the Finnish settler has been to erect a one- or two-room dwelling near one boundary of his land and to clear a roughly semicircular plot of land of about an acre During the winter he earns money with which to purchase seed for planting by working in the woods as a lumberjack The following spring crops are planted, and more land is cleared The old axiom, "Where there is a Finn there is a cow," holds true At the earliest possible date a cow and a cow barn are added to the meager equipment of the farm This one cow is the beginning of the relatively large number of cattle and chickens which are kept The process is slow, but time and effort are of no importance Slowly the Finn converts a seemingly worthless tract into a paying farm

The average farm of the community (Map 10 and Pl LXIX, Fig 1) contains approximately eighty acres Of this perhaps forty acres are cleared and put in condition suitable for the production of crops. This small area is again divided into twenty-six acres in hay, six in oats, three in potatoes, with the remaining five acres utilized for miscellaneous crops such as sunflower and millet [8] The crop rotation is, usually, oats, hay, and potatoes Few fields lie fallow because of the restricted area of cultivable land

Probably the most striking feature of the Finnish farm is the great number of buildings. These may range from the original small shack which was the first dwelling of the farmer, through several types of hay barns, tool sheds, and cattle barns, to the more modern

[8] Putnam, George W, "The Financial and Social Factors Affecting the Development of Successful Farms and Prosperous Farm Communities in Alger County," a paper read at the Land Utilization Conference, Munising, Michigan, September, 1932 Pp. 1–4 of mimeographed copy

THREE REPRESENTATIVE FINNISH FARMS



MAP 10

dwelling and latest type of combined animal and hay barn with all modern appliances Two structures which are always present are the bathhouse and the hay barn The former is generally located at some distance from the others in order to decrease the danger of fire rather than because of a desire for privacy, since it is the custom for all members of the family to bathe together, regardless of sex (Pl LXIX, Fig 3) Often neighboring families may call at bathing time The hay barn may be distinguished by the large spaces between the logs and the slight inward slope of the walls The former feature tends to insure the proper curing of the hay while in storage, the latter protects the logs of the walls from wet rot (Pl LXX, Figs 1–2)

The dwelling of the farmer presents an interesting picture Set well apart from the buildings of the barnyard because of the danger of fire, it contrasts with the closely grouped habitations of areas near by The long experience of the Finn in the use of the ax has made him an excellent woodsman This one implement and his inexhaustible patience have combined to make the town of Eben It has aided him to develop submarginal land, to earn money through the winter, and thus increase the earnings of his little farm, and to construct the buildings on the farm without resort to the more expensive milled lumber Owing to the absence of chinking, the squared logs, and neatly finished corners, the numerous log buildings contrast sharply with the log structures found in other parts of the state Over the house is a roof of typical Finnish origin, called *walmdach* or "hipped roof" This consists of a long sloping back roof, which may be broken slightly to increase the head room in the kitchen, which is usually a wing added to the rectangular house The front portion of the roof is more steeply pitched The unequal pitching of the roof may be the result of a desire to keep an insulating blanket of snow over as large a portion of the dwelling as possible

Field Practices

The many peculiarities in agricultural, economic, and cultural practices which the Finn has brought with him are generally based on some sound reason developed after long experience in a similarly unfavorable environment

Chief among the agricultural practices is the predominance of

crops primarily utilised for cattle consumption, as is shown by the maps This is in turn a result of the Finnish preference for a meat diet as well as of the climatic conditions of the area The percentages of crops given earlier in this paper are borne out by the maps

With such an emphasis upon hay and grain crops it is essential that they be preserved for winter use In an area with so restricted a growing season it has been found advisable to allow the grain to ripen in the fields prior to the storage in barns The method employed for curing small grains has been directly transferred from the home land to the Eben district A light staff is driven into the soil, and a cross piece is fastened to it a short distance above the ground On this the partly ripened grain is placed The increased angle of repose of the grain which is stacked in this fashion insures a rapid run-off of precipitation, the cross piece elevates the base of the stack and allows adequate aëration (Pl LXX, Fig 3)

Corn is stored on an adaptation of the former rack and, since this crop is not native to Finland, it is logical to suppose that the innovation occurs in this district The increased weight of the crop has necessitated a heavier frame This is constructed in the form of a large sawhorse, against the cross piece of which the corn is stacked This crop is not used as silage, as is the custom elsewhere in northernmost United States, but instead the ears are husked and stored in cribs Since the stalk and the leaves of the plant are not utilized, it is possible to allow the base of the plant to rest on the ground (Pl LXX, Fig 4)

Some Social Aspects

Coöperative tendencies traceable to the home land are manifested in the Eben community by the presence of the "Rock River Co-operative Agency" This establishment serves not only as an investment but also as a collective buying and selling organization which enables the members to dispose of their crops at more favorable prices and to purchase articles at greatly reduced cost This store has been considerably weakened by the tendency of the Finns to join the Communist party

Communist activities have induced a number of the younger men of the community to return to southeastern Finland, near the Russian border These individuals not only have gone but have taken with them money and equipment such as tractors and other farm

PLATE LXIX

FIG 1 A representative Finnish farm Note the irregular pattern of fence lines and the large number of buildings

FIG 2 A typical stump pasture The first step in the preparation of the land for crop use

FIG 3 A representative Finnish bathhouse with neatly worked corners and close fitting squared logs

PLATI IXX

FIG 1 A large hay barn

FIG 2 Another type of hay barn with noticeable spacing of logs and a slight inward slant of walls

FIG 3 Haystacks in a field The end of an upright support may be seen emerging from the top of the steeply pitched pile

FIG 4 The method of stacking corn in the field This appears to be an adaptation of the method shown in Figure 3

machinery The situation has not as yet become serious If continued it may lead to the forced abandonment of a portion of the land which is now under cultivation, because of a depletion of the finances of the district as well as a dearth of individuals able to work the soil

CONCLUSION

The Finnish farmer is an industrious, pioneer settler working in an environment similar to that of his native land His adaptation of agricultural, economic, and cultural methods to the environment of the Eben district has enabled him to build a small but efficient community in an area which has been unattractive to immigrants of other nationalities The experience and working habits of the individual as well as of the group recommend the Finn as the type of immigrant most desired to settle the cut-over, submarginal land of the Great Lakes district

UNIVERSITY OF MICHIGAN

STRUCTURE AND PHYSIOGRAPHY OF THE SOUTHERN WASATCH MOUNTAINS, UTAH

ARMAND J EARDLEY

CONTENTS

LOCATION

THE southern Wasatch Mountains are situated in central Utah and comprise the southern end of the Wasatch Range, which extends southward from a point near the Idaho line to the town of Nephi, a distance of 150 miles The area mapped is 22 miles long in a north-south direction and 11 miles wide, and includes the southern Wasatch Mountains, part of the Wasatch Plateau to the east, part of the Gunnison Plateau to the south, and part of the Juab

and Utah valleys to the west, in which the towns of Santaquin and Nephi are situated

Structure

There have been four major crustal disturbances in the region of the southern Wasatch Mountains, namely the post-Archean revolution, the post-Algonkian revolution, the Laramide revolution, and the Basin and Range deformation During the Paleozoic and Mesozoic eras minor disturbances occurred in the form of epeirogenic movements, and, preceding the Laramide revolution, in the form of normal faulting The geologic history is summarized in Table I at the end of the paper

PRE-LARAMIDE CRUSTAL DEFORMATION

The post-Archean revolution was probably more intense than any that occurred afterward Sedimentary rocks were converted into schist and gneiss,[1] these were intruded by pegmatite dikes and granite, and all were later truncated by erosion The Algonkian shale and quartzite now cover this old erosion surface The unconformity thus created may actually be the result of a number of distinct disturbances, now all compounded into one great hiatus The foliation of the schist and gneiss strikes roughly parallel with the axes of the much later Laramide folds, indicating that the structural lines of this ancient period of diastrophism may have exerted some control over the present Rocky Mountain trends of the region

At the close of the Algonkian era of deposition a compressional orogeny occurred in which great folds were formed The magnitude of these folds in the region around the southern Wasatch Mountains may be estimated by the amount of erosion that followed The maximum observed thickness of the Algonkian strata in the Wasatch Mountains is about 11,000 feet In Dry Mountain of the southern Wasatch Mountains a thickness of only 1,000 feet is found It is, therefore, suggestive that folds having an amplitude of at least 10,000 feet were created in this post-Algonkian revolution

During the Paleozoic and Mesozoic eras gentle epeirogenic warpings occurred, producing hiatuses in which most of Ordovician, Silurian, Devonian, and parts of Triassic and Jurassic times are

[1] Eardley, A J, "Stratigraphy of the Southern Wasatch Mountains, Utah," *Pap Mich Acad Sci, Arts and Letters*, 18 (1932) 311 1933

not accounted for[3] These hiatuses are marked only by disconformities not easily discernible and by low-angle unconformities

Preceding the Laramide folding normal east-west faulting disturbed the region A number of east-west faults are in the area mapped, and all have been classified as "pre-Laramide," although in only one instance can an exact age determination be made On the north side of the mouth of Santaquin Canyon an east-west fault is cut by the Santaquin overthrust and is, therefore, older than the thrusting The others are similar to this one inasmuch as they are all older than the Basin and Range block-faults, and none have topographic expression except that which is due to the relative resistance of the rocks on one side or the other

LARAMIDE CRUSTAL DEFORMATION

The dominant structure built during the Laramide revolution in the southern Wasatch Mountains is a great overturned and overthrust fold involving a series of strata in excess of 20,000 feet in thickness With this as a key, all other features can be demonstrated to be incidental but interesting variations of the major structure The block diagram of Figure 9 is an attempt to reproduce the position of the folded strata as they would have appeared if no erosion or block-faulting had subsequently occurred and if the earth's crust had remained rigid enough to support such an excess of weight as that imposed by this fold The diagram is not complicated by any of the minor variations that exist

The following points constitute a brief description of the Laramide structure

Folding

The great anticlinal fold is practically isoclinal and overturned from Pole Canyon No 2 south Farther north in the Dry Mountain area it is broader and, so far as exposed, not overturned In that part which is isoclinal only the post-Cambrian strata are involved, but in the open fold the entire rock section is engrossed The range from North Canyon to Dry Mountain is sculptured out of the east limb of the open fold, whereas the beds in Mount Nebo are carved out of the lower limb of the overturned fold The dip in Dry Mountain is about 30° E and in Mount Nebo about 30° W In Loafer

[3] *Ibid*, pp 317–334

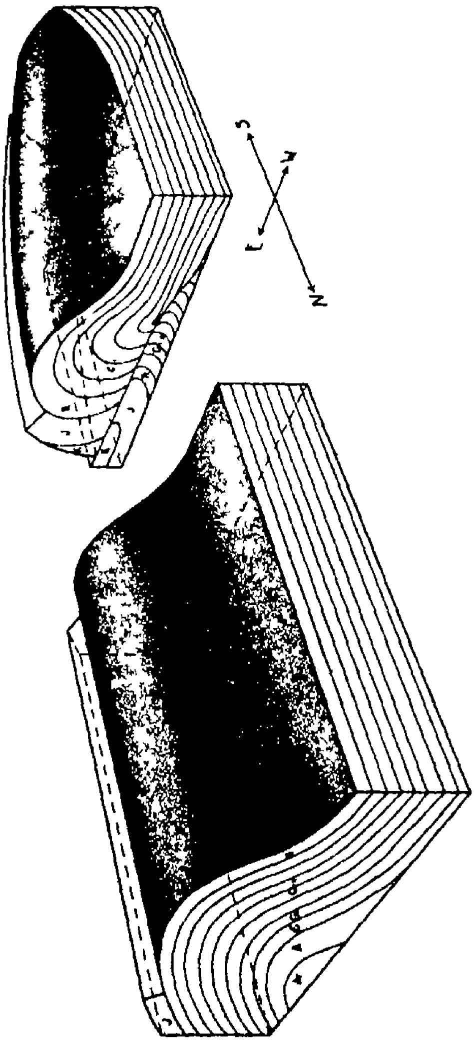


Fig. 9. Block diagram illustrating the author's conception of the structure produced during the Laramide revolution in the southern Wasatch Mountains. The area included in the diagram is approximately that of the geologic map (Map 11)

Mountain, which is a continuation at deeper horizons of the Dry Mountain structure, now brought up by Basin and Range block-faulting, the dip is over 45° E This may suggest that the fold continues at depth to an overturned position here also

The axis of the fold trends slightly east of north, except at the southern end, where it veers decidedly to the west This swing to the west is indicated by the present strike of the beds and by the exposure of the Paleozoic strata not to the south, but to the southwest, in the Canyon Range of the Great Basin

The trace of the axial plane traverses the present erosion surface at approximately the junction of the piedmont with the steep slopes of the Wasatch front At the north end of the mapped area the trace of the axial plane lies slightly west of the mountain front (Dry Mountain) From this point it continues about due south, crossing the ridge formed by the "Intercalated series" on the southwest side of the mouth of Santaquin Canyon The axis of the fold is seen at the very mouth of Dry Canyon In North Canyon the strata are arched, with a small western segment of the arch showing, indicating the axis here to be slightly to the east of the mountain base In Pole Canyon No 2 the axis is also decidedly within the mouth of the canyon, and continues so through Bear Canyon and Couch Canyon The rocks at the mouth of Willow Creek show intense twisting and brecciation, with varying strikes and dips, which are thought to indicate the close proximity of the axial plane of the fold From Willow Creek to Gardner's Canyon the axial plane follows in general the base of the mountain front, and then, from consideration of the strike of the axis, it is thought to swing off to the southwest

Overthrusting [1]

The Nebo overthrust — An overthrust fault is mapped skirting the southern base of Mount Nebo It is recognized by the following evidence

1 The Intercalated series of Pennsylvanian age rests on Jurassic shale (see geological map [Map 11]) in Gardner's Canyon

[1] In order to avoid the question of "overthrusting" or "underthrusting" some authors have used the term ' thrust fault" or simply "thrust " In general the term "overthrust" has been used in the Rocky Mountains, and for this reason it is retained here. For the same reason, where direction of thrust is stated, it always has reference to the overriding block. The writer desires to remain noncommittal on the subject of overthrusting vs. underthrusting in this article

2 Three Triassic formations, the Woodside, Thaynes, and Ankareh, are found in the North Fork of Salt Creek Canyon, but are absent in Gardner's Canyon About 2,500 feet of strata are missing The mapping of the Woodside, Thaynes, and Ankareh formations shows them all to disappear, one at a time, when followed around the High South Ridge of Mount Nebo, until finally the Intercalated series rests on the Jurassic shale

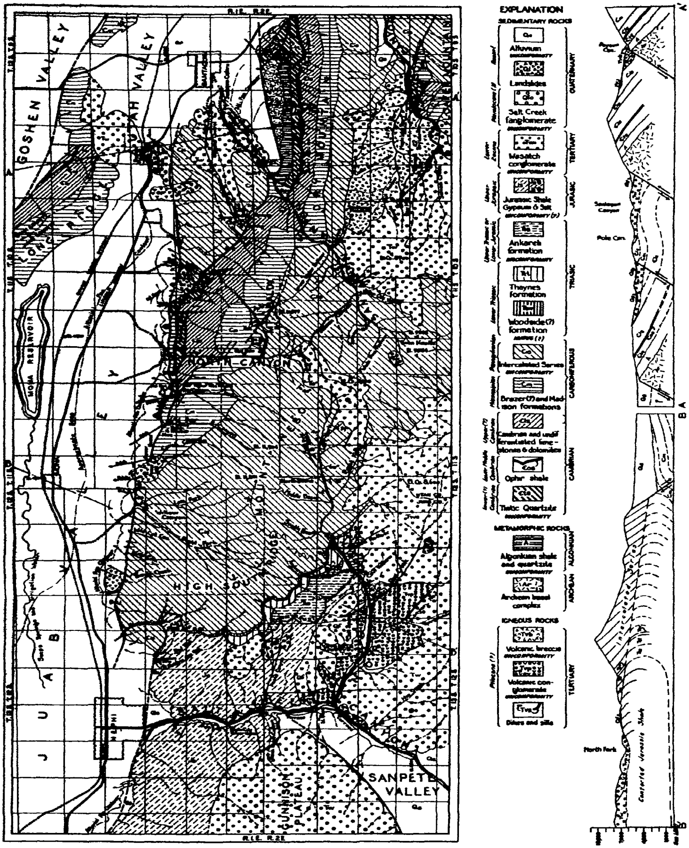
3 The fault plane is mapped as lying at the base of the overturned flank of the single great fold of which the southern Wasatch Mountains are composed It is probable that under continued horizontal pressure the overturned fold would have ruptured at this position

4 In the North Fork of Salt Creek Canyon the Ankareh and Jurassic shale contact is an angular one, and appears to be the result of overthrusting There are two possible interpretations of this angular contact first, an erosional unconformity, and, second, an overthrust fault The writer believes the latter interpretation correct because

(*a*) The upper beds of the Ankareh dip 45° NW as they emerge from under the Tertiary cover in the North Fork of Salt Creek Canyon The dip of the plane that truncated them is only 12° W This plane falls in line with the plane of the overthrust, where it is more definitely located

(*b*) There are no basal conglomerates or sediments of any kind to suggest an erosional unconformity. Where the contact is exposed, an oölitic limestone of rather pure calcium carbonate is the lowest bed of the Jurassic series

(*c*) In the study of the Triassic and Jurassic sections both north and south of Thistle Junction, a point about 15 to 20 miles to the northeast of Salt Creek Canyon, a cross-bedded sandstone, generally considered to be the Nugget formation, overlies the true Ankareh Above this sandstone, probably disconformably, is a marine limestone, which is commonly referred to the Twin Creek horizon But in the exposure on the east wall of the North Fork of Salt Creek Canyon, both of these formations are absent, and it is unlikely that an episode of erosion following the Twin Creek stage of deposition could have occurred so locally as to account for the absence of these two formations when a similar erosional break a short distance northeast in the Wasatch is not found



GEOLOGIC MAP AND SECTIONS OF THE SOUTHERN WASATCH MOUNTAINS, UTAH

BY A. J. EARDLEY

Scale $\frac{1}{62,500}$

1934

MAP 11

(*d*) Intense brecciation is noted in the immediately overlying Ankareh shale and sandstone

In view of this evidence there is postulated in the sharply bent return of the overturned fold a fracture that produces the inception of an overthrust The horizontal movement along this fault has been small and is thought to die out to the north and increase to the southwest, because the overturning of the fold dies out to the north and the stratigraphic break becomes greater to the southwest

This fault will be referred to as the "Nebo overthrust" See Figures 9 and 11, and Plate LXXII, Fig 1

Santaquin overthrust — In the Dry Mountain section of the great fold of the southern Wasatch Mountains the exposed strata dip east and are not in overturned position Slipping of the beds over one another has occurred, and is chiefly concentrated in the Ophir shale, a noncompetent bed between two very competent beds, the Tintic quartzite and the Cambrian limestones Slipping is inconspicuous where the normal sequence of the beds is unaffected, but with the occurrence of preëxisting transverse normal faults, disarrangements of the normal sequence of the strata occur and produce structures to all appearances like major overthrusts Such a fault is found in the lower part of Santaquin Canyon See Map 11

Here a prefolding fault has dropped Mississippian limestones opposite the Cambrian and Algonkian series of strata When movement of considerable magnitude was concentrated along the Ophir shale this adjacent block of limestone was sheared off, leaving the overriding massive Cambrian limestones continuous above the quartzite and the limestone blocks alike With subsequent Basin and Range faulting on the west, this limestone block is now bounded completely by faults The plane of slipping in the Ophir shale and the actual overthrusting of the Cambrian limestones over the Mississippian limestone in Santaquin Canyon will be referred to as the "Santaquin overthrust," and it is so labeled on Map 11

At the north end of Dry Mountain the Santaquin overthrust is well exposed where a prospect drift, known as the "Syndicate Tunnel," runs in, just under the Cambrian limestone A large-scale corrugated and slickensided surface indicates the direction of the movement to be N 75° W

References

An overturned fold has been recognized by Schneider [4] in the Wasatch Mountains in Rock Canyon east of Provo This is much like the Nebo structure, but it has been studied only in cross-section and, therefore, its north and south projection is not well known

Overthrusts have been described in the Park City district by Calkins,[5] Loughlin,[6] and Hintze [7] In general, these thrusts are rudely parallel to the tilted sedimentary strata, though they locally cut the beds at all angles They appear to have been affected by folding or tilting after the thrusting They are older than the intrusive rocks and than most of the other faults

Blackwelder's paper [8] on the Wasatch Mountains, in which he recognizes the Willard and other overthrusts in the northern Wasatch, is well known The fault planes there dip to the east, and would at first suggest overriding from the east This idea has been incorporated in Flint's paper,[9] in which he attempts to apply the wedge theory of diastrophism to the Rocky Mountains It may be a fallacious deduction because of the evidence to the contrary furnished in the central and the southern Wasatch Mountains, where the direction of thrust as manifest in the Rock Canyon and Nebo overturned folds is from west to east From recent field work in the Beartooth-Bighorn region [10] of Wyoming and Montana, however, it has been demonstrated that the thrust in the central part of the range is toward the east, whereas in the wing sections it is toward the west Such a reverse relationship may exist in the Wasatch Mountains The problem must remain unsettled for the present.

Throughout the whole length of the Wasatch Mountains thrusting and overturning may be postulated as an integral part of the structure, with the possible exception of the central portion, where

[4] Schneider, Hyrum, "A Discussion of Certain Geologic Features of the Wasatch Mountains," *Journ Geol*, 33 39–40 1925

[5] Calkins, F C, *Ore Deposits of Utah, U S Geol. Surv, Prof Paper 111*, p 245 1920

[6] Loughlin, G F, "Reconnaissance in the Wasatch Mountains, Utah," *Journ. Geol*, 21 439–443 1913.

[7] Hintze, F F, Jr, "A Contribution to the Geology of the Wasatch Mountains, Utah," *Annals New York Acad Sci.*, 23 133. 1913

[8] Blackwelder, Eliot, "New Light on the Geology of the Wasatch Mountains, Utah," *Bull. Geol. Soc Am*, 21 533–539 1910

[9] Flint, R. F, "Rocky Mountain Structure," *Journ Geol.*, 32 410–431 1924.

[10] Thom, W T, Jr, personal communication

the Uinta arch meets the Wasatch Range It has been found in the Nebo district that intense brecciation indicates proximity not only to faults, but also to the axis of isoclinal folds

Crustal shortening

In order to arrive at an approximate figure of the amount of crustal shortening localized in the southern Wasatch Mountains a bed about in the center of the exposed sedimentary rock series was selected for measurement A bed higher up in the series would yield a greater figure and one lower in the series a smaller A reconstruction of the fold as it affected this bed was drafted to scale, and the amount of shortening was found to be approximately twelve miles An additional mile of shortening may have occurred in the thrust, especially in the vicinity of Gardner's Canyon, where the Intercalated series rests on Jurassic shale The total shortening in the southern Wasatch may be roughly estimated as thirteen miles

Age of Laramide deformation in the southern Wasatch Mountains

The youngest beds affected by the disturbance in the area mapped are Upper Jurassic in age In areas not far distant, however, younger beds have been upturned and eroded In Lake Fork, a tributary to Soldiers' Creek near Thistle Junction, Schneider has recognized Colorado beds standing nearly vertical In Six Mile Canyon, near Manti, Wasatch beds rest unconformably upon beveled edges of vertical Montana and Colorado strata, [11] in a more detailed discussion of the problem in the Wasatch Plateau Spieker and Reeside [12] state that "in this disturbance the rocks up to and including the Price River formation were folded by intense compression" The Price River formation is the uppermost of four formations included in the Mesaverde group Spieker and Reeside suggest that it agrees closely in age with the Fruitland and Kirtland formations of the San Juan Basin and the Laramie formation of the Denver Basin

The folded and truncated beds are overlain by the Wasatch conglomerate, which has been determined as Lower Eocene [13]

[11] Thom, W T Jr , personal communication

[12] Spieker, E M , and Reeside, J B , Jr , "Cretaceous and Tertiary Formations of the Wasatch Plateau, Utah," *Bull. Geol Soc Am* , 36 445 1925

[13] Eardley, A J , "A Limestone Chiefly of Algal Origin in the Wasatch Conglomerate, Southern Wasatch Mountains, Utah," *Pap Mich Acad Sci , Arts and Letters*, 16 (1931) 399–414. 1932

The date of the Laramide revolution in the southern Wasatch Mountains may thus be limited to that period of time intervening between early Paleocene and Lower Eocene Whether the revolution, as it affected the southern Wasatch Mountains, was recurrent throughout the greater part of Paleocene time, or whether it was confined to some definite part of the Paleocene, is not discernible from the evidence at hand

BASIN AND RANGE CRUSTAL DEFORMATION

Nature of faulting

The block-faulting of the Basin and Range disturbance is exceptionally well exposed in the southern Wasatch Mountains Here recent movements along the major fault planes and remnants of the downthrown blocks still unburied by alluvium have revealed with unusual clearness the detail of the fault system The dominant structure of the region mapped is a normal fault zone running slightly east of north, with the east block raised and tilted, forming a bold escarpment 4,000 to 7,000 feet high Figure 10 is a stereogram representing the writer's conception of the block-faulting of the area, on the assumption that no erosion took place during faulting and that the surface broken by the faults was a peneplane Neither of these assumptions is warranted except, possibly, for purposes of illustration A comparison of this stereogram with the geologic map (Map 11) will serve to identify the various faults The numerous east-west normal faults are considered to be older than the block-faults of the Basin and Range disturbance, as previously stated, and are not represented on the diagram

A small part of Long Ridge is included in the map of this report The block-faulting of this ridge has been studied by several geologists, the most recent of whom is Eaton [14] His conclusions coincide with those of the writer in respect to the fault on the northwest side of the Long Ridge and, therefore, this particular part of the work is not original It will be seen by comparison of the cross-sections in Eaton's paper with those in this report that the general ideas are the same, but that detailed study has added to, and somewhat altered, the conceptions as expressed in the diagrams by Eaton

[14] Eaton, Harry N, "Structural Features of Long Ridge and West Mountain, Central Utah," *Am. Journ Sci.*, Fifth Ser, 18 71-79 1929

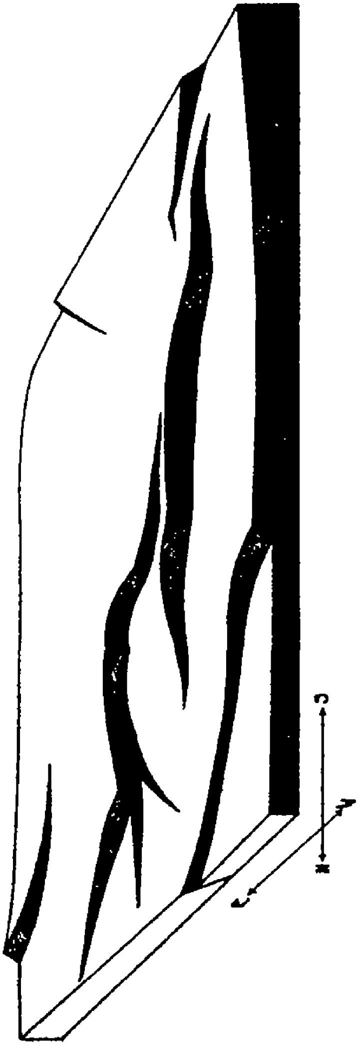


FIG 10 Block diagram of the Basin and Range faulting in the southern Wasatch Mountains. Compare with geologic map (Map 11). The region was not peneplained before the inception of faulting as the diagram indicates, and erosion reduced the fault scarps as faulting progressed. In these respects the drawing is not correct, but for illustrative purposes the restoration is, perhaps, justified

Throw of fault

On the north side of the mouth of Santaquin Canyon the upper part of the Mississippian has been faulted down to the bottom of the Algonkian, making a displacement of about 5,500 feet

On the south side of the same canyon the bottom beds of the Intercalated series have been dropped about 2,000 feet below the base of the Cambrian limestones This displacement amounts to about 5,900 feet

The fault which extends up Payson Canyon has a much smaller displacement than the two just mentioned It is the southern end of the major Wasatch fault of the Utah Valley arc [15] An east-west fault of earlier date than the Payson Canyon fault, which it intersects, has placed Cambrian quartzite at the same elevation as Mississippian limestone The later Payson Canyon fault has dropped beds of the Intercalated series opposite the Mississippian limestone on one side of the east-west fault and the Cambrian quartzite on the other side The total displacement of the Payson Canyon fault must, therefore, not include the throw of the earlier fault, but is to be measured by the relationship of the Mississippian limestone to the beds of the Intercalated series This measurement amounts to approximately 2,000 feet The Payson Canyon fault is believed to decrease in throw rapidly southward, where it disappears in a volcanic breccia

The vertical displacement of the mountain block above the valley block in the Santaquin-Nebo district, on the basis of these measurements, is thought to be throughout most of its length at least 5,000 feet and not more than 6,000 feet The relief of Mount Nebo in excess of this figure is explained by the theory of strong relief before block-faulting [16]

Dip of fault plane

Two parallel faults of the Basin and Range orogeny cross the mouth of North Canyon An old prospect hole follows down along a silica gouge zone on the eastern of these two faults just north of

[15] Gilbert, G K, *Studies of Basin-Range Structure, U S Geol. Surv, Prof Paper 153*, p. 20, Fig 12 1928

[16] Eardley, A J, "Strong Relief before Block-Faulting in the Vicinity of the Wasatch Mountains," *Journ Geol*, 41 243-267 1933

the canyon The footwall is the fault plane The dip, definitely defined, is 50° W

At the mouth of Santaquin Canyon the trace of the main fault is seen on the south wall and, if the writer's interpretation of the structure is correct, measures about 50° W

A study of the geologic map (Map 11) will indicate that the fault planes have a considerable inclination to the west

These data correspond with those gathered by Gilluly in the Oquirrh Mountains [17] to the northwest He recorded an average dip of 54° for faults of Basin and Range age He also discusses the figures of lower dips as published by Davis and Gilbert, and the higher dips as published by Pack It will not be necessary, therefore, to review this argument Suffice it to say that the writer's observations in the southern Wasatch concur with those of Gilluly's in the Oquirrh Range, which fact adds additional weight to the conclusion that the major faults of the Basin and Range orogeny in the vicinity of the Wasatch Mountains dip about 50°–55°

Laramide structural control

The stereogram, Figure 11, shows the relation of the axial plane of the large Laramide anticlinal fold to the normal fault system of the later Basin and Range deformation It will be noted that the main line of faulting closely follows the trace of the axial plane of the fold It is thought that the axial plane of the fold represents the zone of greatest fracturing of the rocks deformed during the Laramide revolution and, therefore, the locus of the subsequent normal faulting of the southern Wasatch Mountains

Age of Basin and Range faulting

Since its initiation the block-faulting of the southern Wasatch Mountains has continued intermittently to the present There have been movements along the fault planes which have left very fresh escarpments in the valley alluvium, and hence must not far antedate the arrival of the early settlers in the valley

The time of commencement of the faulting postdated the Wasatch conglomerate (Lower Eocene) and also the extrusive igneous rocks which overlie the Wasatch conglomerate, because the faults

[17] Gilluly, James, 'Basin Range Faulting along the Oquirrh Range, Utah,' *Bull Geol. Soc Am* 39 1123–1124 1928

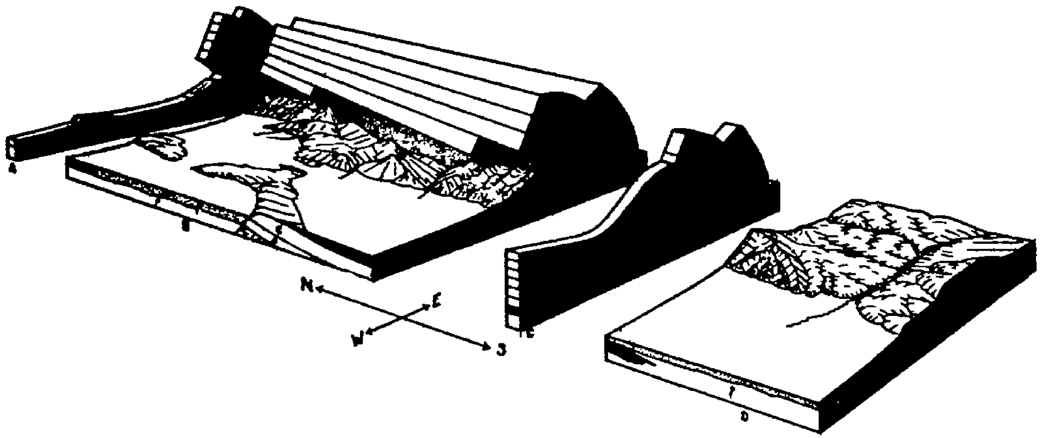


FIG. 11 Block diagram of the southern Wasatch Mountains representing the Laramide and Basin and Range structures combined with partial restoration of the strata. Block *A* shows section through Dry Mountain, Block *B* the development of the nearly symmetrical fold at Dry Mountain to the overturned fold at Mount Nebo, Block *C*, complete restoration of strata as effected by both orogenies, Block *D* the Salt Creek Canyon area as it is today The four blocks should be imagined as pushed together for a composite picture

out them both There are no younger sedimentary rocks in the region, and hence no accurate conclusion regarding the age of the faulting can be reached on the basis of stratigraphy There is, however, a certain amount of physiographical evidence which can be brought to bear on the subject It will be presented later

Physiography

Since the Laramide Rockies were formed in the region of the southern Wasatch Mountains four distinct, if only partial, cycles of erosion have occurred The evidence for this conclusion comes from a study of two buried surfaces now exposed by deep dissection, and of the existing surface, which reveals an interruption of a third cycle and an inauguration of a fourth

PRE-WASATCH CONGLOMERATE TOPOGRAPHY

The rise of the Laramide Mountains resulted in the dissection and then partial burial of a surface having a relief of at least 10,500

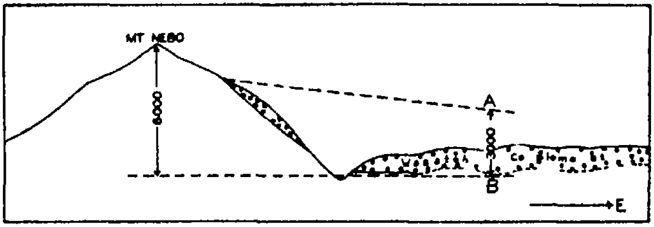


Fig 12 Section through Mount Nebo, showing pre-Wasatch conglomerate surface

feet This figure is ascertained by the study of the surface upon which the Wasatch conglomerate of Lower Eocene age rests Figure 12 is a cross-section of Mount Nebo, showing the present remnants of the conglomerate and the surface upon which they lie If to the relief of this latter surface the amount of erosion it suffered previous to the deposition of the conglomerate may be added, the total height of the Laramide Mountains in this vicinity may be approximately determined

The relief represented between the base of the conglomerate and the top of Mount Nebo is 5,600 feet It is estimated that the thick-

ness of the conglomerate is about equal to the reduction by erosion which the land area suffered in supplying the conglomerate material Mount Nebo was part of the area eroded [18] The original thickness of the conglomerate may be conservatively estimated to be 3,000 feet See Figure 12, A–B

To this must be added the amount of erosion that Mount Nebo has suffered since the Wasatch conglomerate itself has been undergoing erosion, which process dates back to early Eocene time This may be crudely estimated as 2,000 feet by assuming that one foot of rock is removed each 10,000 years and that the Eocene is 20,000,000 years old [19]

If the three figures, 5,600, 3,000, and 2,000, be added together, the total relief at the close of the Laramide revolution just prior to the deposition of the Wasatch conglomerate may be obtained, it is found to be, roughly, 10,500 feet

PRE-VOLCANIC TOPOGRAPHY

The Wasatch conglomerate, after being deposited at the base of the mountains created during the Laramide revolution, was itself attacked by erosion which, by Miocene (?) time, had left a topography with considerable relief This surface was partly preserved under a cover of volcanic ejectamenta

In order to measure the relief just prior to the volcanism the same method will be used as in the preceding paragraphs on the pre-Wasatch conglomerate topography Mount Nebo rises about 6,000 feet above the lower limit of the volcanic deposits To this figure must be added the amount of reduction in elevation that Mount Nebo has suffered by erosion since the Miocene (?) This must necessarily be less than the estimate of 2,000 feet of erosion since Eocene time, and by the same method of calculation must be about 1,000 feet By adding, then, the present relief of the old surface, 6,000 feet, and the amount reduced by erosion since, 1,000 feet, a total relief of about 7,000 feet must have existed just prior to the middle or late Tertiary volcanic activity

Post-volcanic erosion resulted in the reëxcavation of the major

[18] Eardley, as cited in note 13, p 406, Fig 14.

[19] Pirsson, L V, and Schuchert, C, *A Text-Book of Geology*, Part II, Second edition, p 105 1924, Fenner, C N, "The Analytical Determination of Uranium, Thorium, and Lead as a Basis for Age Calculations," *Am Journ Sci*, Fifth Ser, 16 369–381 1928

drainage channels that existed before the volcanism Remnants of the pyroclastics may be seen along the present valley walls of Salt Creek Canyon [30] and its North Fork, which were filled in by torrential streams disposing of an excess load imposed by the eruption of large amounts of fragmental material This cycle of erosion continued, it is thought, without interruption until the block-faulting of the Basin and Range orogeny began

PRE-BASIN AND RANGE FAULTING TOPOGRAPHY

By this time the mountains had been materially subdued, so that a submature surface with relief of about 3,500 feet existed The evidence bearing upon this problem has been treated in a separate publication [31] and, therefore, will not be repeated here However, the physiography of Salt Creek Canyon deserves special mention

A reference to photographs, Plate LXXI, will reveal the fact that the present Salt Creek Canyon is but a recent and narrow incision into the floor of a much wider and older valley The latter is four miles wide and, although remnants of a flood plain are lacking, probably displayed characteristics of maturity [32] This older valley is by far the largest of any transecting the Wasatch Mountains It is postulated, like the others, to have existed before the block-faulting began and to have drained a large area to the east of the range The great size of the valley suggests the possibility that it was the course of a master stream draining a considerable area to the east and carrying the waters to the present Great Basin region, through which they might have flowed even to the Pacific In order that this point may receive convincing support the study must be made regional, which has not yet been done

Block-faulting transverse to the course of Salt Creek interrupted the cycle of erosion by tilting the Wasatch Mountain block eastward and dropping the valley block, thereby rejuvenating the stream Incision was greatest at the fault scarp and died out gradually upstream See Figure 11 and Plate LXXI, Figures 1–2

A very recent episode of faulting is responsible for fresh scarps in the alluvium from Wash Canyon to Nephi They occur at the

[30] Eardley, *op cit*, pp 339–342

[31] Eardley, as cited in note 15

[32] The Salt Creek conglomerate was deposited as a veneer on a pediment developed from the High South Ridge out to the valley floor

junction of the steep mountain front with the piedmont The displacement of these recent slippings is not more than 100 feet Plate LXXII shows two photographs of that portion of the recent fault scarp of which Davis speaks [23] "An excellent example of repeated faulting is seen in a fan about three miles northeast of Nephi The earlier fault has a displacement of about 100 feet [corrected by the writer to 65 feet], then a valley several hundred feet wide was opened in the uplifted part of the fan, after this a smaller displacement of about 20 feet [corrected to 30 feet] occurred, making a very light colored band along the base of the earlier scarp and continuing for a mile or more southward through the piedmont waste slope"

AGE OF BASIN AND RANGE FAULTING

The time of the initiating of the block-faulting of the eastern part of the Great Basin has been variously determined as middle Miocene,[24] close of the Miocene,[25] close of the Miocene or possibly "well into the Pliocene",[26] post-Eocene, and also later than the pyroclastic and lava rocks which in the High Plateaus of Utah overlie the Eocene sediments,[27] middle and late Tertiary,[28] and late Tertiary [29]

In harmony with Westgate's determination in the Pioche district (last reference) the following conclusions regarding the age of the faulting in the western part of the Great Basin may be cited, Ferguson believes that the block-faulting in western Nevada is late Tertiary and Pleistocene,[30] Louderback concludes, from strati-

[23] Davis, W M, "The Wasatch, Canyon, and House Ranges," *Harvard Coll, Mus Comp Zoöl*, Bull 49 3 1905

[24] Schneider, as cited in note 4, p 45, *Idem*, "Mid-Tertiary Deformation of Western North America,' *Trans Utah Acad Sci*, 2 159–160 1918–21

[25] Pack, F J, "New Discoveries Relating to the Wasatch Fault," *Am. Journ Sci*, 11 399 1926

[26] Beeson, J J, "Mining Districts and Their Relation to Structural Geology," *Trans Am. Inst Min and Met Eng*, p 14 1925

[27] Dutton, C E, "Geology of the High Plateaus of Utah," *U S Geog and Geol Surv, Rocky Mt Region*, pp. 69–81 1880

[28] Huntington, Elsworth, and Goldthwait, J N, "The Hurricane Fault in the Toquerville District, Utah," *Harv Coll. Mus Comp Zoöl.*, Bull 42, pp 220–222 1903.

[29] Westgate, L. G, and Knopf, Adolf, *Geology and Ore Deposits of the Pioche District, Nevada, U S Geol Surv Prof Paper 171*, p 25 1932.

[30] Ferguson, H. G., "Late Tertiary and Pleistocene Faulting in Western Nevada" (abstract), *Bull Geol. Soc. Am.*, 37 164 1926

graphic and physiographic evidence in eastern California, that the faulting began in "late Pliocene or post-Pliocene time The greater part of the deformation was completed before the late Pleistocene, and while movements have taken place at intervals up to within a few years, the Recent displacements are only a small fraction of the total "[31]

The faulting may not have begun at all points in the Great Basin at the same time and, therefore, it is probably not safe to rely entirely on the preceding type of diastrophic correlation The conclusions reached by this method may be strengthened, however, by a comparison of Pleistocene erosion of a number of different ranges in the Rocky Mountains with that of the Wasatch If no greater denudation or gorge cutting has occurred in the Wasatch than in other ranges under somewhat comparable conditions where the present erosion cycle is known to date only from late Tertiary or early Pleistocene time, then the faulting of the Wasatch, which inaugurated the present cycle of erosion there, must have begun also at this late geologic time

In the case of the Sierra Nevada, where Blackwelder has recognized a fourth stage of glaciation, which he thinks may represent the Nebraskan stage of the Mississippi Valley, erosion has occurred to such an extent that the drift of this earliest epoch is now found only on high divides and isolated mountains He concludes that it must antedate the present eastern front of the range with its deep canyons [32] These canyons are even greater in size than the post-faulting gorges of the Wasatch, such as Provo Canyon, American Fork Canyon, Ogden Canyon, and Spanish Fork Canyon and, inasmuch as faulting in the Wasatch has provided steep gradients conducive of rapid erosion, it appears probable that the canyons in the Wasatch are as young as those of the Sierra Nevada

The San Juan Mountains of southwestern Colorado provide another good example with which to compare the post-faulting erosion of the Wasatch Atwood and Mather [33] have ably demon-

[31] Louderback, G D, "Period of Scarp Production in the Great Basin," *Univ of Cal. Publications in Geological Sciences*, 15 1–38 1924–26

[32] Blackwelder, Eliot, 'Pleistocene Glaciation in the Sierra Nevada and Basin Ranges," *Bull Geol Soc. Am.*, 42 904. 1931

[33] Atwood, W W, and Mather, K F, *Physiography and Quaternary Geology of the San Juan Mountains, Colorado, U S Geol Surv, Prof Paper 166*, pp 25–31 1932

strated that there have been two main cycles of erosion in this range since the beginning of Pleistocene time The earlier of these progressed in general to the condition of late maturity when the first of the three glacial stages occurred, namely, the Cerro, which the authors have tentatively correlated with the Illinoian, but which Blackwelder,[34] Leverett,[35] and McClintock [36] believe to be of Kansan age The depth of these mature valleys ranged from 600 to 2,500 feet Domal uplift then occurred, causing in some places the youthful incision of canyons into the bottoms of the mature valleys to a depth of 1,500 feet It is evident, therefore, that Pleistocene erosion in the San Juan Mountains (*ca* 4,000 feet) has been commensurate with or even greater than that of the Wasatch Mountains (*ca* 3,000 feet), since the Basin and Range block-faulting inaugurated the gorge cycle of erosion

The Grand Canyon of the Yellowstone has been eroded, partly filled, and reëxcavated to a depth of 1,100 feet since the deposition of an early (?) Pleistocene drift on the plateau surface [37]

There are other ranges in the Rocky Mountains where an old glacial drift has been observed, but where erosion has not been so vigorous as in the three instances cited above It is believed that uplift with consequent rejuvenation has been less intense in these cases than in the Sierra Nevada, San Juan, and Wasatch Mountains and that, therefore, a comparison with them would not be justified On the basis, then, of a correlation of magnitude of erosion in the Sierra Nevada, San Juan Mountains, and Yellowstone Plateau the writer concludes that time has been ample for the erosion of the large cross-canyons of the Wasatch during Pleistocene time If this is true, then the block-faulting which initiated the gorge cycle of erosion must date from the close of Tertiary time or the beginning of Pleistocene time

A comparison of the geologic history of the Wasatch region with that of southeastern Idaho shows a close accord of events up to and including the deposition of the Pliocene Salt Lake formation [38]

[34] Blackwelder, as cited in note 32, p 918

[35] Oral communication

[36] Oral communication

[37] Holmes, W H, "Glacial Phenomena in the Yellowstone Park," *Am Naturalist*, 15 203-208 1881, Jones, O T, and Field, R M, "The Resurrection of the Grand Canyon of the Yellowstone," *Am. Journ. Sci*, 27 260-278 1929

[38] Marsell, R E, Geology of the Jordan Narrows Region, Traverse Mountains, Utah (*in manuscript*)

Block-faulting of the Basin and Range orogeny divides the sequence of events at this point, since it occurred in the Wasatch Mountains but not in southeastern Idaho This fact lends support to the theory that the time of initiation of the block-faulting was late Tertiary, post-dating the deposition of the Salt Lake formation in Pliocene time

It is noteworthy that the greater part of the faulting occurred before the Iowan (?) stage of glaciation

Atwood [39] and Gilbert [40] both observe the association of the terminal moraines of Little Cottonwood Canyon, Bell Canyon, South Dry Creek Canyon, Bear Creek Canyon, and Alpine Canyon with the sediments of Lake Bonneville These moraines are thought to belong to the "earlier glaciation" of Atwood and have been determined as Iowan (?) by Blackwelder [41] They post-date any considerable fault displacement, and, therefore, it may be concluded that the greater part of the faulting occurred before Iowan (?) time

In spite of the lack of stratigraphic evidence later than Lower Eocene time in the Wasatch Mountains, it may be concluded with a fair degree of assurance that the block-faulting of the Basin and Range orogeny commenced either at the close of the Tertiary or the beginning of the Pleistocene and continued intermittently until the present, with most of the displacement occurring before the Iowan (?) stage of glaciation

GLACIATION

The only evidence of glaciation that the writer has observed in the southern Wasatch Mountains is in the form of cirques on either side of the high peaks of Mount Nebo Those on the west slopes are particularly well developed, but at present are partly filled with much talus material It is assumed that the ice did not extend far below the mouth of the cirques, since no morainal material was noticed The glaciation was much more intense farther north in the central Wasatch and in the Uintas

It is thought that no previous glaciations, such as are recognized

[39] Atwood, W W, *Glaciation of the Uinta and Wasatch Mountains, U S Geol Surv, Prof Paper 61*, pp 78–83 1909

[40] Gilbert, G K, *Lake Bonneville, U S Geol Surv, Monograph 1* pp 306–315 1890

[41] Blackwelder, Eliot, "Correlation of Glacial Epochs in Western United States," *Bull Geol Soc Am*, 41 91–92 1930 *Idem*, as cited in note 32, p 918

TABLE I

OUTLINE OF THE GEOLOGIC HISTORY OF THE SOUTHERN WASATCH MOUNTAINS

ERA	PERIOD	EPOCH	STAGE	GEOLOGIC EVENT
Cenozoic	Quaternary	Recent		Inhabitation of region by early settlers
				Faulting of alluvial fans built across block-faults
				Amelioration of climate with increasing aridity Shrinkage of Lake Bonneville to Great Salt Lake
		Pleistocene	Wisconsin	Lake Bonneville. Maximum size at maximum extent of glaciation. Rose to overflowing of basin rim. Cut down outlet rapidly and fell 300 feet
				Glaciation. Mountains had become high enough to catch increased precipitation of Wisconsin Stage and were glaciated for the first (?) time. An older glaciation (Iowan ?) is recognized in the central Wasatch Mountains
			Iowan Illinoian Kansan Nebraskan	Outlet of drainage to Pacific cut off
				Silting up of down-faulted areas and back valleys
				Erosion of gorges 3,000 feet deep through uptilted mountain block
				Formation of fresh-water lakes in down-faulted areas
				Continuation of block-faulting Most of 6 000 feet displacement completed before Wisconsin Stage (before Iowan (?) Stage in central Wasatch)
	Tertiary	Pliocene ?		Crustal disturbance. Initiation of block-faulting of Basin and Range orogeny
				Erosion, leaving surface with relief of 3,500 feet Drainage now from east to west
		Miocene ?		Mineralization Emplacement of lead-zinc ore deposits
				Vulcanism. Sill and dike intrusions and extrusion of andesite breccia and pyroclastics
				Erosion, leaving surface with relief of 7 000 feet
		?		Hiatus ?
		?		Erosion. Disappearance of Lower Eocene lake and erosion of conglomerate and highlands
		Lower Eocene		Sedimentation. Torrential streams from highlands deposit 3 000 ± feet of coarse conglomerate (Wasatch conglomerate) at base finer material to east
				Erosion leaving relief of 10 000 feet or more. Highlands to west fresh-water lake to east
Mesozoic	Cretaceous	Post-Price River and pre-Wasatch		Crustal disturbance Great compressional orogeny (Laramide revolution) Formation of overturned fold and thrust fault. Thirteen miles of shortening
		Montana		Sedimentation Shore line shifted eastward, with deposition of fresh-water sediments over marine Colorado
		Colorado		Sedimentation. Coarse influx of boulders, pebbles, and sand from west into sea of Colorado age
				Crustal disturbance. Normal east-west faulting
				Crustal disturbance. Uplift of land to the west, probably beginning of Laramide revolution
		L. Cretaceous		Hiatus. Lower Cretaceous time not represented

Era	Period	Events
Mesozoic	Jurassic	Sedimentation. Thick marine series of buff shale and thin-bedded limestone and sandstone. Upper Jurassic fossils
		Crustal disturbance. Vertical movements and erosion occurred during all or part of Lower Jurassic time
	Triassic	Sedimentation 1 400 feet of deep red, arkosic sandstone, possibly fresh-water (Ankareh)
		Crustal disturbance Epeirogenic warpings and erosion
		Sedimentation. 1 000 feet of marine, buff fine-grained sandstone and arkose (Thaynes)
		Sedimentation 500 feet of limestone and red shale (Woodside?)
	?	Hiatus. No Permian fossils found and no apparent unconformity
Paleozoic	Pennsylvanian	Sedimentation in slowly subsiding geosyncline of 10 000 ± feet of interbedded sandstones and limestones. Pottsville and post-Pottsville fossils (Intercalated series)
		Submergence
	Mississippian	Erosion Black shale and Braser limestone removed locally
		Crustal disturbance. Epeirogenic warpings
		Sedimentation. Black shale
		Sedimentation. Limestone with Braser fossils
		Sedimentation Limestone and dolomite with Madison fossils
		Sedimentation Thin wind-blown sandstone Near shore deposit
		Submergence of older limestones
	?	Crustal disturbance. Very gentle crustal movement resulting in hiatus
		Sedimentation Undifferentiated limestones no fossils found There are probably hiatuses
	Cambrian	Sedimentation. Ribbon and oölitic limestone and dolomite
		Sedimentation Shale and thin-bedded sandstone with lower Middle Cambrian fossils. (Ophir shale)
		Sedimentation. Sandstone, later turned to quartzite (Tintic quartzite)
		Submergence of Algonkian erosion surface
Algonkian		Erosion of Algonkian beds. Reduced to thickness of 500 feet
		Crustal disturbance. Folding
		Sedimentation. 10 000 feet of red sandstone and variegated shale of fresh-water (?) origin. Red sandstone later changed to quartzite
		Submergence of Archean erosion surface
Archean		Truncation by erosion of schist gneiss granite and pegmatite
		Crustal disturbance Profound orogeny
		Intrusion of granite and pegmatite into schist and gneiss
		Metamorphism of granite (?) and shale (?) into gneiss and schist
		Intrusion (?) of granite?
		Sedimentation (?) of shale?

in the Sierra Nevada, occurred, either because the Wasatch Mountains did not reach sufficient height as a result of block-faulting until the Iowan (?) stage of the Pleistocene or because the snow fields were too limited

Outline of Geologic History

The outline on pages 398 and 399 of the geologic history is confined to the events as they occurred in the southern Wasatch Mountains For certain age determinations the writer has sought evidence outside the immediate region in consideration The outline is to be read from bottom to top

University of Michigan

PLATE LXXI

Fig. 1. Photograph of Salt Creek Canyon looking east. The mountains rise abruptly from the alluvial flats of the valley along the Wasatch fault. The dark lines indicate the sharp incision of the present Salt Creek Canyon into an older and much broader valley. The High South Ridge is on the left and the Gunnison Plateau is on the right.

Fig. 2. Photograph of upper Salt Creek Canyon, looking east, taken at the junction with the North Fork. The entrenchment of the stream here is is not so great as at the mouth of the canyon, as shown in Figure 1, and gradually dies out upstream.

PLATE LXXII

FIG. 1. Mount Nebo from the east. The strata forming the upper part of the mountain are all overturned. The line of dashes indicates the approximate trace of the Nebo overthrust.

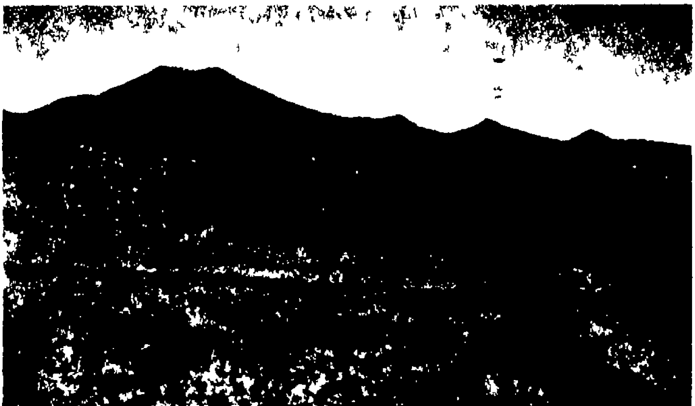


FIG. 2. Scarp formed by two recent movements on the Wasatch fault plane at the mouth of Gardner's Canyon. The scarp is about one hundred feet high. The High South Ridge is in the background.

PLEISTOCENE POTHOLES IN THE CLOCHE MOUNTAINS OF ONTARIO

GEORGE M STANLEY

INTRODUCTION

THE presence of some gigantic potholes near the north shore of Lake Huron was made known to the writer by Professor William Sargent, of Detroit Since these potholes were in close proximity to shore formations being studied by the writer's party at the time, late in August, 1932, and since they were unusual in both their great size and topographic position, two days were devoted to making a detailed survey of them

The location of the potholes is shown in Maps 12–13, and it may be more accurately described as follows Along the eastern extent of the Cloche Mountains, which border the North Channel and face Great Cloche Island, and due north of tiny Carpmichael Island there is an unusual accumulation of terraced shore deposits, quite conspicuous from the water, as is also "the Sugarloaf," a rocky knob rising a hundred feet or so above them It is in this vicinity, only a few hundred feet north of the Sugarloaf, that the 56 potholes were found A total of 49 are described, of which 17 are fractional, i e with a portion of the circle absent

DESCRIPTIONS OF POTHOLES

The surveying (by hand level) to the adjacent beach formations rendered it convenient to ascertain the elevations of the various potholes above the lake All were floored with loose débris, mostly of a fine sort, and floor elevations were taken to the surface of this débris The rock bottoms of most potholes lie at unknown depths below the so-called floor, and in only one was excavation attempted

The main group of potholes, numbering 25 and including the most magnificent, is on the south slope of the quartzite knoll (encircled in Pl LXXIII, Figs. 1–2) just north of the Sugarloaf To the east a few hundred feet two adjacent quartzite outcrops have

8 and 12 potholes each These are surrounded by surface deposits which perhaps conceal other potholes A few more are to be found, however, on occasional outcrops still farther east and beyond the trail

Pothole *A* is the most striking of all, though it is not the largest It is about 12 feet in diameter and almost circular Its walls rise above the floor of alluvium to a height of about 7 feet, they show distinctly the rounding effect of the water action, with traces of undercutting, resulting in an increased diameter below the top The floor is covered with low shrubbery, and two jack pines 5 and 8 inches in diameter are growing in it Pothole *A* is one of the highest of the group, its floor has an elevation of 342 5 feet Formerly, when water cascaded over the hillside, this hole was at the head of a series by which the water passed The minimum elevation of its wall on the upstream side, its threshold, is 348 8 feet The most distinguishing feature of pothole *A* is its outlet trough or spout (see Pl LXXIV, Fig 1, Pl LXXV, Fig 1), there is no previous record of such a spout in the literature At its brink this trough is slightly over a foot wide and 344 0 feet in elevation, and leads directly down to pothole *B* One's first impression is that it was made by the overflow of water from pothole *A* to pothole *B*, but a little reflection leads one to consider that such a small stream as would fill this trough would scarcely have the power to carve such gigantic potholes, and that one should regard this trough as formed by a train of débris borne in the bottom of a torrent, which did not just flow through this spout, but completely submerged it Certainly this small spout does not measure the stream of water that eroded the potholes

The largest entire pothole is *B*, with a diameter of 15 feet Its walls, somewhat undercut, are only from 2 to 5 feet high, its floor elevation is 335 feet A pine 8 inches thick grows in it As has been said before, pothole *A* was tributary to *B*, also tributary to *B* were potholes *X* (floor 351 5 feet) and *Y* (floor 349 0), and, in order, *T* (floor 350 4) and *S* (floor 345 6)

After passing pothole *B* (see Map 12), the water cascaded from a shelf of rock (336 4 feet) and plunged straight down into pothole *C* (floor 317 3), which has a wall height of 19 feet Although this is the largest (see Pl LXXV, Fig 2), with a diameter of some 20 feet, it is not entire, but consists of a semicircular scallop cut

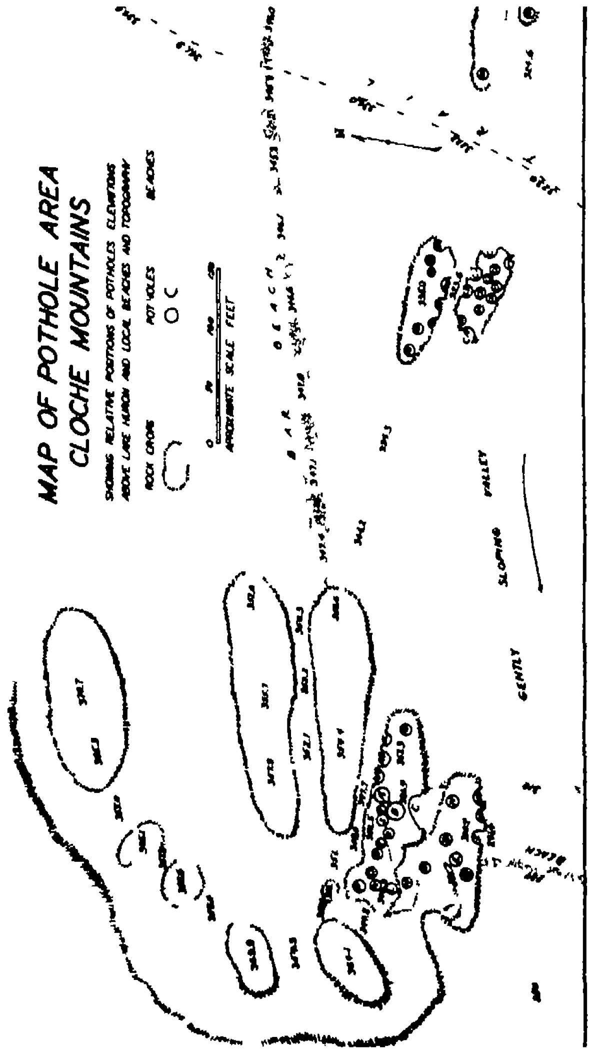
into the quartzite, and is open to the south It is not perfectly semicircular, but somewhat parabolic, the flatter edge being to the west The walls of pothole *C* are clearly water-worn, although there has been some subsequent weathering, it is evidence of powerful erosive action

The water from pothole *C*, merging with that from *D* (floor 309 7 feet), made a similar fall over another ledge (300 4) into pothole *F* (floor 281 4), thus dropping 19 feet or more here Pothole *F*, only 7 feet in diameter, is open to the south and faces the Sugarloaf across a little westward-sloping valley full of shore deposits As to the course and erosion of the water below here one cannot tell, because of concealment of the bedrock by the lake alluvium

Excavation of one of the smaller potholes, *1D*, was tried A heterogeneous mixture of sand, gravel, and stones as large as apples was removed slowly, the latter with considerable difficulty, owing to their being tightly wedged in This pothole is 1 5 feet in diameter at the mouth, but somewhat larger below At a depth of 2 feet excavation was abandoned, it could have been continued only with a crowbar (see Pl LXXVI, Fig 1) In two very small potholes, *X* and *Y*, the rock bottom was visible after the removal of small clumps of humus and grass, but the majority are filled or floored with much alluvial débris, including certainly the former tools, and are somewhat grown over Water and marsh grass were observed in one or two, for example, in pothole *AX* (see Pl LXXVI, Fig 2)

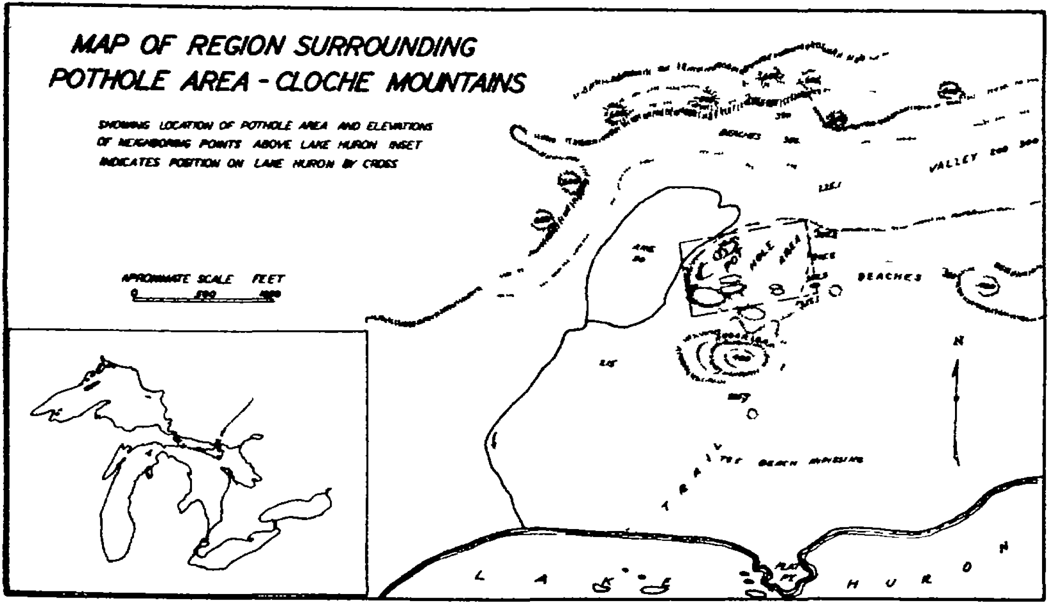
There seem to be three types of potholes represented here, although not always distinct from one another (1) those formed possibly by a sheet or current of water passing over the almost horizontal surface into which they were drilled, as shown by potholes *AD* (Pl LXXVI, Fig 1), *AX* (Pl LXXVI, Fig 2), *L*, *M*, *E*, *G*, *AY*, *BX*, *BY*, *CK*, *CI*, *DA*, and others, (2) those fashioned by plunging of water, such as *F* and *C* (Pl LXXV, Fig 2), and, in some measure, *A* and *B*, (3) fractional ones cut in a vertical wall, with the energy coming probably from a stream of water passing at the side, such as *AA*, *AB*, *AC*, *UA*, *UB*, *BV*, *AU*, *AV*, *CJ*, and others This grouping is not by way of general classification, but only for analysis of the local problem

The surfaces of the smaller potholes are smooth and polished, apparently just as when formed Weathering has somewhat marred the larger, pothole *C*, and to a lesser degree *A* and *F* Adjacent to



MAP 12

(See Map 13 for general location)



Map 13 Sketch map of the pothole area of the Cloche Mountains. The rectangle north of the Sugarloaf indicates the area shown in Map 12

AD (Pl LXXVI, Fig 1) may be seen angular corners of the quartzite ledge, as though weathering had taken place on these surfaces since the pothole was formed In no case could the effects of glacial abrasion be seen, indeed the hard quartzite in which the holes occur seems nowhere in the vicinity to have been striated Whether they were ever overridden by the glacier after their formation cannot be answered by this test Besides the potholes there are many obviously water-rounded and scoured surfaces close by, suggestive also of strong water action

Detailed descriptions of all the potholes would be lengthy, and also incomplete without excavation, which would be a laborious task The accompanying table gives the most significant data concerning them (1) the estimated maximum diameter, although the diameter does not vary much in any of these potholes, which are generally fairly round, (2) the greatest height of the wall above the floor of débris which fills a pothole, or above the rock bottom noted in a few instances, although such height varies considerably for some potholes and in fractional ones, not entirely circular, becomes 0 on one side, (3) the elevation of the floor above Lake Huron, (4) the elevation, where determined, of the threshold or top of wall, over which water had to flow to enter the potholes The letters represent potholes as indicated on the sketch map (Map 12) Elevations given to decimals are determinations by hand level and rod, those without decimals are by aneroid The elevation of one of the peaks to the north was measured (640 feet), the others were estimated

TOPOGRAPHIC RELATIONS AND COURSE OF THE MELT WATER

It is probably more than a coincidence that near these potholes is found the largest accumulation of glacial débris along this face of the Cloche Mountains, namely, the terraced lake deposits adjoining the Sugarloaf A great bar terrace at about 345–350 feet ties the Sugarloaf to more easterly hills, and beaches have been formed in this at lower levels The present beach at Flat Point is a great alluvial flat The Cloche Mountains form a barrier along the shore here, and some 400 to 700 feet above it, with a broad lowland to the north occupied by the Spanish River and numerous lakes About one mile to the northeast of the Sugarloaf, however, there is a cleft in this barrier, a valley about 200 to 300 feet in

TABLE I

Table of Potholes

Elevations to decimals by hand level others by aneroid

Pothole	Diameter in feet	Observed depth or height of wall in feet	Floor elevations above Lake Huron (not rock bottom) in feet	Threshold on top of wall
A	12	7	342 5	348 8 (outlet spout 344 0
B	15	5	335	344 0
C *	10	19	317 3	336 4
D	4	4	300 7	313 0
E	4	3	303 2	306 0
F *	7	19	281 4	300 4
G	3	3 5	292 1	295 7
H	5	3	314 9	
X	1 5	1	351 5	352 5
Y	1 5	1	349 0	
U	3		351 9	
T	4	2	350 4	
S	6	4 5	345 6	350 1
P	4	1	350 ±	
N	1 5	1 5	347 4	
O	1 5	1 5	347 0	
L	3	3	341 2	344 3
M	3	2	337 5	
AM	4	3	327 9	330 9
AA *	6		347 2	
AB *	10		344 3	
AC *	3		342 0	
AD	1 3	2	329 4	331 4
UA *	12	12	315	
UB *	8	6	312	
AY	2	1 5	328 9	
AX	4	3	331 9	
AW *			331 3	
AV *	10		326 9	
AU *	10	5	324 1	
BV *	6	1	331 0	
BX	1 5	1	327 8	
BY	1 5	1	327 8	
CA *	6	3	321 7	
CB *	3	2	323 4	
CC	5	3	325 3	
CD *	6	4	325 2	
CE	1	1	324 8	
CG	1 5	1	325 1	
CH	3	1 3	325 3	
CI	1 5	1	324 9	
CJ *	8	5	323 0	
CK	2 5		323 7	
CL *	6	2 5	321 6	
CM *	16		320 ±	
DA	1 5	1	324 0	
EA	2	1	321 7	
FA†	1 5	1	322 8	
GA†	1	1	335 ±	

* Fractional pothole
† Not shown on map

elevation above Lake Huron This valley may have offered a convenient passage southward for glacial or subglacial melt water The drift accumulation in the shore deposits was perhaps brought by the same glacial stream which sculptured the potholes A stream coming through this valley today would empty directly into the little lake which lies northwest of the Sugarloaf at an elevation of 190 feet (aneroid), and thence by its outlet to Lake Huron, as may be seen from Map 13 But the potholes are 90–160 feet above this inland lake (281–351 feet above Lake Huron)

It seemed at first that if the lake basin and valley northwest of the Sugarloaf had been filled with ice, stagnant perhaps, a lake might be impounded by this ice and by the beach bar at 345 8–347 0 feet, so as to have its outlet threshold over the hill near the groups of potholes at and around *A* But a close examination, with determination of the elevations in Map 12, showed that this was impossible, the bar beach is scarcely high enough, nor would the potholes to the south of this beach be accounted for, i e *BX*, *AX*, *CC*, *DA*, *EA*, *FA*, *GA*, and others (Potholes *FA* and *GA* are not shown on the map, but are a few hundred feet east of *DA* and *EA*)

The potholes must have been formed when the ice which covered the region directed a rapidly moving stream to the brow of the hill near pothole *A*, around which hill the ground is lower in all directions

One course of the water down the hillside is detailed on pages 402–403 A similar course existed some 50 feet to the west, going successively to potholes *P*, *N* (floor 347 4 feet), *O* (floor 347 0), *L* (floor 341 2), *M* (floor 337 5), *AM* (floor 327 9), *E* (floor 303 2), and *G* (floor 292 1) (See Map 12) Moreover, it is evident from the local topography and the relations of the rims or thresholds of the potholes to the adjacent rock slopes (the rims are frequently higher than the slopes on either side) that there were not just these two distinct cascades, but that the whole intervening area was covered by a moving cataract, and that a column of water some 10 feet deep moved through the passageway (threshold 344 8 feet) west of *P* and down to the southwest, that another moved southeastward down the little channel (threshold 347 7) north of *A*, eroding on its way potholes *AA*, *AB*, and *AC* Scouring action all over the hillside is conspicuous One must here picture a great stream running underneath the ice. It may have fallen much of its time through a crevasse directly upon the area between potholes

A and *P*, spreading out laterally and running off southward down the rock basement, or it may have approached the same area with a more horizontal motion from the northeast From the general appearance of the bed of this torrent down the hill, as compared with the sites of numerous waterfalls seen in streams entering the upper lakes, the writer would estimate a normal discharge here to be perhaps 10,000 cubic feet per second, probably as large as any stream today entering the Great Lakes, except their connecting rivers

The general course of the water near potholes *A*, *P*, *C*, etc, seems to have been as a cascade over the hill from north to south In considering the potholes on the quartzite outcrops just west of the trail, one would prefer to imagine the active stream as moving more nearly horizontal over the surface A like condition would seem to explain those potholes to the east of the trail, *EA*, *FA*, and *GA* A stream active on the groups just west and east of the trail would certainly not at the same time be active on the group about pothole *A*, as may be gathered from the elevation data The possibility that the potholes of the east-west course (*CL*, *BV*, *AX*, *EA*, *FA*, and those near by) might have been formed at the base of moulins occupying successively new positions instead of by a more horizontally moving stream should not be overlooked but seems less likely

Thus there appear to have been two distinct local courses of the water, whether active at one time or not One course cascaded southward down the steep hill, where are *A* to *F* The other led westward down the more gradual slope which runs across the trail to the south of the beach at 346 and through the valley immediately north of the Sugarloaf and past the foot of the cascade first mentioned Here the courses join and continue west through the same valley (see Map 12 and Pl LXXIV, Fig 2) and toward the basin of the small lake below

SHORE LINES AND THEIR RELATIONS TO THE POTHOLES

It is quite apparent that the erosion of the potholes took place prior to the formation of the adjoining beaches From a glance at Map 12 it is clear that the cascade from potholes *G* and *F* and others would have destroyed the beach at 284, had it then been present, also the stream from potholes *AX*, *CC*, etc, would have swept away the beaches to the west Moreover, the floors of pot-

holes *F*, *UA*, and *UB* are continuous with and a part of the shore deposits of the valley floor That the potholes were a result of shore or lake action is not to be considered, their depths, shapes, magnitudes, and vertical range all distinguish them unmistakably from potholes of this origin

There are strong bar beaches at 346 and 328 adjacent to the pothole area and incidentally reaching about the same elevation as the highest of them At the east end of the beach at 346, however, is a succession of short beaches up to 360, still higher, where the trail climbs the slope of the ridge north of the potholes, it crosses a strong set of rubble beaches ranging from 356 7 to 390 6 feet

Beaches of the upper Algonquin group are strongly developed at 360 to 433 feet above lake level along the brow of the escarpment behind Little Current in the northern part of Manitoulin Island [1] Correlatives of these must exist along the Cloche Mountains, eleven miles to the north, even though absence of the very highest of the series might be explained by the position of the ice border If one makes allowance for northward rise, the highest Algonquin beaches should be expected in the pothole region about 480 feet above Lake Huron Considering the terrain there, the writer was not in the least surprised at failing to find them, but they would surely be discovered by a prolonged and intensive search

The ice border was receding northward across this area about the time of the three-outlet phase or Port Huron Chicago stage of Lake Algonquin [2] Regardless of the exact time of this recession in lake history, the glacial lake was then at least 40 feet (as indicated by the writer's beach at 390 6), and more probably 130 feet (as indicated by highest Algonquin), higher than the highest potholes, and some 200 feet above the lowest of the pots (*F*), it could not have been lower If the potholes were then in process of formation, the sculpturing stream, which entered this lake, was under hydrostatic pressure where it passed over the potholes, probably by as much as 130–200 feet head of water A precisely similar relation can be seen by analysis to hold for the great potholes observed by McKellar [3] on the north shore of Lake Superior The writer can

[1] Writer's unpublished notes and data

[2] Leverett, F L, and Taylor, F B *U S Geol Surv*, *Mon 53*, pp 438–439 1915

[3] McKellar, Peter, "Pot Holes North of Lake Superior Unconnected with Existing Streams," *Bull Geol. Soc Am*, 1 568–570 1890

see no sound way of avoiding the conclusion that, if these potholes were in process of formation toward the close of the last glacial period, they were formed by streams under hydrostatic pressure

ORIGIN OF THE POTHOLES

Discussion of giant potholes formed by glacial moulins has been presented by many writers, especially Upham[4] He sees difficulty in the theory that the moulin remained stationary for a period long enough to erode potholes, unless at an early or late date in the glacial period, when ice motion was negligible Manning[5] notes the view of Agassiz that, owing to reforming of crevasses in the same locality, the moulin might remain stationary though the ice advanced The writer wishes to point out that the majority of such potholes are on the tops or high slopes of hills[6] Upham reviews numerous instances Would it not be natural for hills to cause the formation of crevasses?

The potholes of the Cloche Mountains do not seem to be necessarily of moulin origin From what the writer has seen of potholes in existing streams, he would consider that no great moulins were necessary for production of the ones in question Some of them, such as *B*, *C*, and *F*, and a few others, are of the plunge type described by Elston,[7] and involve considerable descent of the water, but this would have been natural on the hillside where they occur

It is questionable whether potholes of the moulin or plunge type could be formed by water under hydrostatic pressure Water freely falling would seem more natural for their production, but no definite data to decide this are available

If the Cloche potholes were not formed under hydrostatic pressure, they must have originated at an early time in the glacial period, when, for some reason, glacial lakes did not surround the ice to great depths, as at the close of the Pleistocene And in this case they might be considered remarkably intact

[4] Upham, Warren, "Giant Kettles Eroded by Moulin Torrents *Bull Geol Soc Am*, 12 25–44 1900

[5] Manning, P C, "Glacial Pot Holes in Maine' *Proc Portland Soc Nat Hist*, 2 185-200 1901

[6] Upham, *op cit*, McKellar, *op cit*, Manning *op cit* Barker E E, "Glacial Pot Holes at Crown Point, New York,' *Journ Geol*, 21 459–464 1913

[7] Elston E D, ' Pot Holes, Their Variety, Origin and Significance, ' *Scientific Monthly*, 5 554 567 1917, 6 37–51 1918

Similar reasons have led to the belief that potholes along the coasts of Maine and Norway were formed early in the glacial period [8] Elsewhere some have been found with glacial markings on them [9] The exact time relations and hydraulic conditions of formation of the potholes described must remain at present a problem

SUMMARY AND CONCLUSIONS

1 A group of 56 potholes, drilled in quartzite, from 1 to 20 feet in diameter, within an area 200 by 800 feet, on the summit and slopes of a hill, 281 to 352 feet above Lake Huron, were found north of Manitoulin Island

2 The potholes were formed by a glacial stream previous to the making of the beaches in the region, and when ice covered the surrounding lowlands The stream was probably responsible also for great drift accumulations in the vicinity, and was perhaps attracted here by a marked rift in the east-west Cloche Mountain barrier to the north

3 They were formed perhaps by moulins, but not necessarily by the great tumble of water through deep crevasses, which is suggested by this word If the ice could have supported the stream of water and directed it to the hilltop around which the potholes occur and there freed it, its part would have been sufficient

4 The potholes either (*a*) were formed by a stream under great hydrostatic pressure or (*b*) were made previous to the recession of the last ice sheet [10]

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[8] Upham, *op cit* [9] McKellar, *op cit.*

[10] After this paper had gone to press the writer saw a few long-abandoned potholes near Whitefish Falls, Ontario, about nine miles east by north of the group described Though much inferior in development and fewer, they appear likewise to have been produced by Pleistocene stream action, for they are far out of reach of ordinary river floods. They are about 50 feet above and 400 feet west of the Whitefish River, just below the logging chute and the bridge of the Algoma Eastern Railway

PLATE LXXIII

FIG. 1. Looking north from the Sugarloaf. The hill on which the potholes are developed is encircled. Pothole C, twenty feet in diameter with a nineteen foot wall in back, is in the smaller circle. In the distance is Cloche Mountain Ridge.

FIG. 2. Looking south from the Cloche Mountains toward the Sugarloaf and the North Channel of Lake Huron. The hill with the potholes is encircled. The Sugarloaf is beyond and higher.

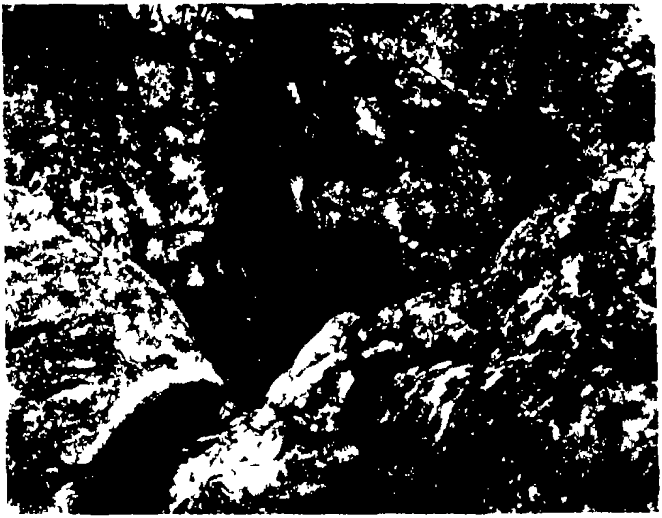

Fig. 1. Pothole 4, twelve feet in diameter. The spout in the lower left corner is a unique feature eroded by the train of departing debris. Undercutting may be observed on the far wall.

Fig. 2. Looking northwest from the north slope of the Sugarloaf across the small valley toward the neighboring lake. In the upper right corner is the steep slope down which formerly cascaded a large volume of water.

PLATE LXXV

FIG. 1. Pothole 1. See Plate LXXIV, Fig. 1.

FIG. 2. Pothole C. This is the largest of the potholes. It is twenty feet in diameter. See Plate LXXIII, Fig. 1.

FIG. 1. This small pot (4*D*) was excavated with great difficulty to a depth of two feet where the bottom was not evident. The stones were tightly wedged in.

FIG. 2. One of the few potholes found full of water, grass, and algae. This pot (4X) is four feet in diameter; the depth is not known.

WELL LOGS IN THE NORTHERN PENINSULA OF MICHIGAN SHOWING THE CAMBRIAN SECTION

FREDRIK T THWAITES

INTRODUCTION

IN 1910 the writer was assigned the problem of the age and stratigraphic relations of the Lake Superior sandstone of Wisconsin His conclusions were published in 1912 as Bulletin 25 of the Wisconsin Geological and Natural History Survey, entitled *Sandstones of the Wisconsin Coast of Lake Superior* It was found that the solution of this problem, namely, the upper limit of the pre-Cambrian of the Lake Superior district, does not lie in Wisconsin but in the adjacent states To the west in Minnesota the drift cover is heavy To the east in Michigan there is lack of areal continuity, for the ridge of Keweenawan traps intervenes between Irving's "Western Sandstone" and the sandstones east of Keweenaw Point at the bottom of the Paleozoic sequence Lack of financial support prevented further investigation on the problem, but in the meantime work was undertaken in northeastern Wisconsin, and extensive studies were made of well logs, including several in the Northern Peninsula of Michigan The present paper does not attempt to settle the problem of the true relation of the marine Paleozoic formations to the older red non-marine sandstones which are involved in the Keweenawan folding and faulting, but only to present some data which bear upon the correlation of the Cambrian section of northern Michigan with the better known formations in Wisconsin

PREVIOUS INVESTIGATIONS

There is very little recent published information on the lower part of the Paleozoic section of northern Michigan, and the work of Rominger[1] is still the most detailed account He applied the name "Lake Superior sandstone" to all the sandstones between the base

[1] Rominger, C, "Palaeozoic Rocks [Upper Peninsula]," *Geol Surv Mich*, Vol 1, Part III 1873

of the "Calciferous" (now Beekmantown) and the underlying traps of the Middle Keweenawan Some sandstone of later age seems to have been included under the same name A division into an upper light-colored member and a lower red member is clearly given [2] The following section was measured on Laughing Whitefish River near Laughing Fish Point (formerly Whitefish Point) in Alger County The description has been changed to conform to current terminology

		Thickness Feet
7	Sandstone, dolomitic, casts of "*Pleurotomaria* (Calciferous")	—
6	Sandstone, massive soft, white makes cliffs	50
5	Sandstone, soft, thin bedded, thin seams of blue shale	75–100
4.	Sandstone, rather soft, thick-bedded, light gray, layers of quartz pebbles, a few feet of dark red coarse conglomerate at the top	?
3	Sandstone coarse hard, red and speckled, heavily bedded, cross-bedded, layers of conglomerate, makes cliffs	15–20
2	Sandstone, fine shaly red, seams of red shale	12
1	Sandstone, thin bedded, red and white, blotched and spotted	25

Irving [3] regarded this section as proving "that in the Eastern Sandstone we have to do with the same formation, or with its downward continuation, as the fossiliferous Cambrian sandstone There appears to be but one way in which this conclusion can be avoided, and that is by supposing that where, east of Marquette, the red sandstone is overlain by the lighter-colored, there is a discordance of greater or less extent, the red sandstone having been thus separated by a relatively large time-gap from that which overlies it This view was, indeed, held as long ago as 1841, by Houghton, who, however, so completely altered his opinion in the next few years "

In 1907 Lane and Seaman [4] proposed to name Irving's Eastern Sandstone "Jacobsville" "while the term *Munising* sandstone is to apply to the upper 250 feet of Lake Superior sandstone which crosses the bluffs back of Munising, dips southerly, and is white or light colored" These authors also quoted the early statement by Houghton and listed a few fossils which had been discovered in the upper sandstones

[2] *Ibid*, p 81

[3] Irving, R. D, "The Copper-bearing Rocks of Lake Superior," *U S Geol. Surv*, *Mon. 5*, pp 351–352 1883

[4] Lane, A C, and Seaman, A E, ' Notes on the Geological Section of Michigan Part I, The Pre-Ordovician," *Journ Geol*, 15 680–695 1907, *Geol. Surv Mich*, *Ann. Rep for 1908*, pp 23–42 1909

The foregoing nomenclature was followed on the geological map published by the Geological Survey of Michigan in 1916

In 1923 the writer[5] published an account of the results of his study of logs of deep wells based on samples In 1931 he was one of the collaborators for the Geological Cross-Section of the Central United States for the Fifth Annual Field Conference of the Kansas Geological Society of Wichita, Kansas This section was published as a blue-line print and was accompanied by a mimeographed explanation in the guide book The route of the section is much the same as that here given, but it was drawn to sea-level datum

In the last few years E O Ulrich of the United States National Museum has collected fossils from the Cambrian of northern Michigan[6]

ACKNOWLEDGMENTS

The writer is indebted to R B Newcombe of the Michigan Geological Survey for unpublished information and for permission to prepare the following paper

COMPARATIVE STRATIGRAPHIC SECTION

Although the purpose of this paper is to present data on the probable correlation of the Cambrian of Wisconsin with that of northern Michigan, it seems necessary to include a discussion of all formations below the easily recognized Trenton (Black River of Wisconsin) dolomite because there seems to have been much confusion in the several interpretations of the underlying Ordovician formations Efforts to recognize the St Peter and Jordan sandstones in well logs have led to ascribing widely different lines of division and therefore to deducing rapidly varying thicknesses for the underlying formations

With the purpose of testing the validity of the several assumptions the writer has prepared the accompanying comparative stratigraphic section (Fig 13), in which the top of the Munising sandstone is shown as a straight line This horizon seems to be the best marked key, for it is a contact between firm dolomite, for the most part red,

[5] Thwaites, F T, "The Paleozoic Rocks Found in Deep Wells in Wisconsin and Northern Illinois," *Journ Geol* 31 529–555 1923

[6] Ulrich, E O, and Resser, C E, "The Cambrian of the Upper Mississippi Valley, Part II Trilobita, Saukiinae," *Bulletin of the Public Museum of the City of Milwaukee*, 12 217 1933

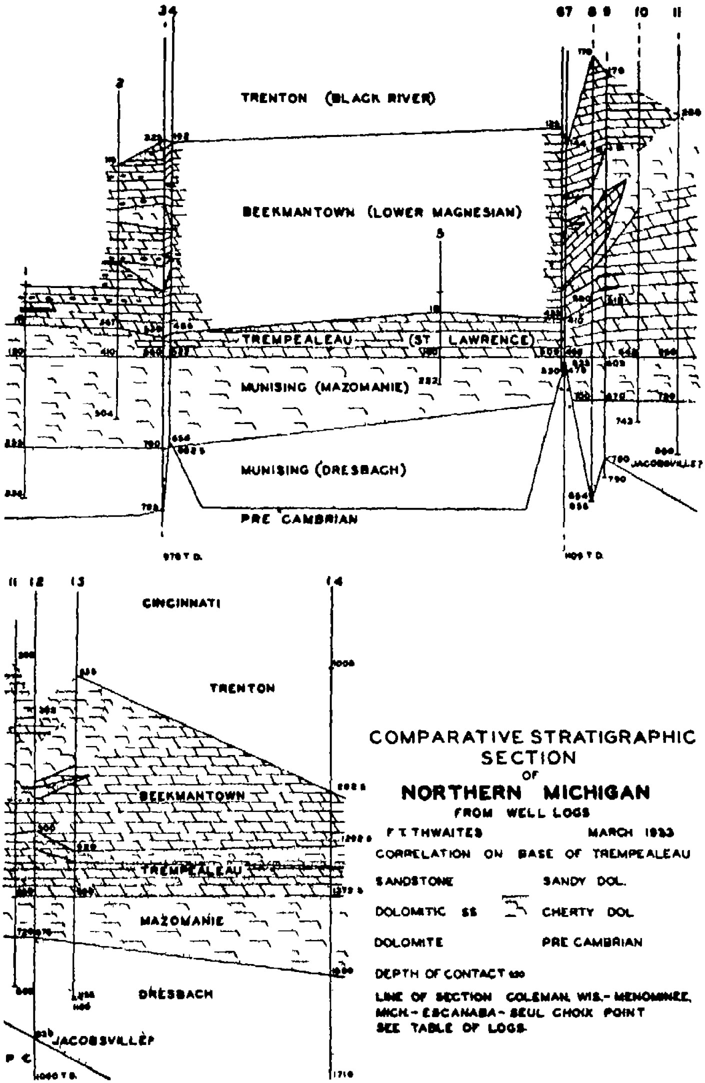
TRENTON (BLACK RIVER)
BEEKMANTOWN (LOWER MAGNESIAN)
TREMPEALEAU (ST LAWRENCE)
MUNISING (MAZOMANIE)
MUNISING (DRESBACH)
PRE CAMBRIAN
JACOBSVILLE?
CINCINNATI
TRENTON
BEEKMANTOWN
TREMPEALEAU
MAZOMANIE
DRESBACH
JACOBSVILLE?
P C
COMPARATIVE STRATIGRAPHIC
SECTION
OF
NORTHERN MICHIGAN
FROM WELL LOGS
F. T. THWAITES
MARCH 1933
CORRELATION ON BASE OF TREMPEALEAU
SANDSTONE
SANDY DOL.
DOLOMITIC SS
CHERTY DOL
DOLOMITE
PRE CAMBRIAN
DEPTH OF CONTACT
LINE OF SECTION COLEMAN, WIS.-MENOMINEE, MICH.-ESCANABA-SEUL CHOIX POINT
SEE TABLE OF LOGS

FIGURE 13

WELL LOGS USED IN PREPARATION OF FIGURE 13

No of location	*Owner*	*Remarks* *
1 Coleman, Wisconsin	Coleman Canning Company	Samples examined by F T Thwaites University of Wisconsin Nos 76444–76514
2 Peshtigo	Peshtigo Pulp and Paper Company	Samples examined by F T Thwaites, U W, Nos. 54155–54255, 54303–54310
3 Marinette	City well No 2	Samples examined by R A Smith, Publ 24, pp 238–239
4 Menominee, Michigan	Menominee and Marinette Light and Traction Company	Samples examined by F T Thwaites, U W, Nos 86432–86558A
5 Powers	Delta-Menominee Sanitorium Sec 16 T 38, R 26	Samples
6 Pine Ridge	Schemmel exploration, Sec 28 T 39, R. 23, Nos 1 and 2	Samples examined by R A Smith and I P Barrett Publ 24, pp 216 218
7 Same	Same No 1 (No 3?)	Diamond drill hole
8 Escanaba	Chicago and Northwestern Railroad shops, Sec 29, T 39, R 22	Samples examined by R. A Smith Publ 24, pp 214–215 and by F T Thwaites, U W, Nos 50416–50452
9 Wells	Escanaba and Lake Superior Railroad, Sec 18, T 39, R 22	Samples examined by F T Thwaites, U W, Nos 84846–84791A
	Escanaba Oil Company, No 1 Stephenson	Samples examined by F T Thwaites and by W Osgood Publ 37, p 282
10 Gladstone	Minneapolis, St Paul, and Sault Ste Marie Railroad, Sec 21, T 40, R 22	Drillers log, possibly with a few samples, Publ 14, p 237
11 Rapid River	Oil test, Sec 34, T 42, R 21	Drillers' log and a few samples, Publ 14, pp 237–238 (May have reached pre-Cambrian)
12 Masonville	Neff well Sec 31, T 42, R 20	Few samples, Publ 14, p 239
13 Nahma	Oil test, Bay de Noc, Sec 20, T 42, R. 19, No 1	Drillers' log
14 Seul Choix Point	Schoolcraft Development Syndicate, Sec 21, T 41, R. 13, No 2	Samples, recorrelated by writer

* The abbreviation "Publ" in this column refers to the publications of the Michigan Geological and Biological Survey

and underlying sandstone Thus it can be identified even in logs not based upon sample examination by a geologist

TRENTON (BLACK RIVER)

In northern Michigan, where the Trenton (Black River of the Wisconsin Survey) is not underlain by St Peter sandstone, discrimination of the base of the formation is dependent on other means So far as the experience of the writer goes, the Trenton dolomite is free of chert On solution in hydrochloric acid a considerable residue of shale is obtained In many places the base of the formation contains large sand grains, greenish gray shale, much pyrite or marcasite, and a peculiar very light gray dolomite

PARTIAL LOG OF WELL OF ESCANABA AND LAKE SUPERIOR RAILROAD, WELLS MICHIGAN

	Thickness Feet	Depth Feet
Dolomite, light gray to gray	30	95
Dolomite, light gray, in part pyritic	20	115
Dolomite, blue and light to dark gray	30	145
Dolomite, gray, bottom pyritic	25	170
Total	105	

Note — top eroded

PARTIAL LOG OF WELL OF PESHTIGO PULP AND PAPER COMPANY PESHTIGO, WISCONSIN

	Thickness Feet	Depth Feet
Dolomite, bluish gray	47	60
Dolomite, light gray	25	85
Dolomite, light bluish gray, part mottled blue and gray	25	110
Dolomite, blue and gray floating sand, sandstone, fine, gray, dolomitic	6	116
Total	103	

Note — top eroded

ST PETER SANDSTONE

To date, the writer has not been able to distinguish the St Peter sandstone as far north as the south end of the section here given At Menominee there is a thin sandstone at the horizon at which the St Peter should occur, but it is far from certain that this is really the St Peter Where it is present in Wisconsin the St Peter invariably lies on the underlying formations, with a marked erosional unconformity Red non-dolomitic shale, locally bleached to a green-

gray color, as well as chert conglomerate, tells positively of emergence Despite the fact that no such strata have yet been found in Michigan the irregularity of the inferred contact of the Trenton with the underlying formation strongly suggests a marked break The drawing of the line on the section is, however, subject to revision in the light of more refined studies of the insoluble residues

BEEKMANTOWN (LOWER MAGNESIAN) DOLOMITE

The Beekmantown formation of Michigan is for the most part equivalent to the Lower Magnesian dolomite of Wisconsin, which is believed to embrace the Oneota and overlying Shakopee dolomites of Minnesota It consists of dolomite which is mainly gray, but which has some red zones, and contains much chert and sand The chert is gray and yellowish gray and occurs in three varieties dense, oölitic, and dolocastic The oolitic chert is a positive marker of the formation Lenses of medium-grained dolomitic sandstone, some of them many feet thick, are abundant throughout the formation Thin laminae of greenish gray shale are abundant The attempts at correlation of the sandstone lenses in Figure 13 should not be regarded too seriously, and the vertical exaggeration of 528 times must also be taken into account The thickness of the Beekmantown as here defined varies from 90 to 380 feet

PARTIAL LOG OF WELL OF MENOMINEE AND MARINETTE LIGHT AND TRACTION CO, MENOMINEE MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, medium gray, very dolomitic, shale, greenish gray	11	203
Dolomite, dark blue-gray very shaly	10	213
Dolomite, gray, shale, greenish gray	12	225
Dolomite, light gray, shale, greenish gray	7	232
Dolomite, gray, floating sand near bottom	23	255
Sandstone, fine, light gray, dolomitic, shale, blue, chert, gray	5	260
Dolomite, light gray, shale, greenish gray	60	320
Dolomite, light gray, very sandy, shale greenish gray	5	325
Dolomite, light gray very fine sand	35	360
Dolomite, gray, pink, sandy, chert, pink and gray	10	370
Sandstone, fine, light gray, dolomitic	15	385
Dolomite, light gray, some fine white sand	50	435
Dolomite, white, thin layers	10	445
Dolomite, light gray, very fine sand	10	455
Dolomite, light gray, fine sand	31	486
Total	294	

PARTIAL LOG OF WELL OF ESCANABA AND LAKE SUPERIOR RAILROAD, WELLS MICHIGAN

	Thickness Feet	Depth Feet
Dolomite, light gray, some dark spots passing below to dark blue and dark gray	40	210
Dolomite, light gray	35	245
Dolomite, light gray and dark brownish gray	5	250
Dolomite, light gray	20	270
Dolomite light gray and greenish gray, pyritic	5	275
Dolomite, light gray chert, white	10	285
Sandstone, medium, gray, very dolomitic, frosted grains	48	333
Sandstone, medium to fine, white	17	350
Dolomite, light gray, very sandy	10	360
Sandstone, medium to fine, light gray dolomitic	5	365
Dolomite, light gray, sandy	10	375
Dolomite, light gray	51	426
Sandstone, medium to fine, light gray, very dolomitic	19	445
Dolomite, light gray	30	475
Sandstone, fine, light gray, very dolomitic	5	480
Dolomite, light gray	15	495
Dolomite, light gray, very sandy	5	500
Dolomite, gray to dark gray	10	510
Total	340	

TREMPEALEAU FORMATION

The term "Trempealeau" was proposed by Ulrich [7] to replace the name "St Lawrence," which had been very loosely used The former name has never been approved by the Board of Geologic Names of the United States Geological Survey Present custom in Wisconsin is to include as Trempealeau all strata from the base of the cherty Lower Magnesian through the lowest firm dolomite layers, which are in most places underlain by a few feet of very glauconitic sandstone conglomerate In part of northeastern Wisconsin the top of the Trempealeau as thus defined is a clean sandstone, which must be equivalent to the original "Jordan" of Minnesota The Jordan sandstone (now regarded as a member of the Trempealeau) is believed by Ulrich and Resser [8] to be the "emergent

[7] Ulrich, E O, "Notes on New Names in Table of Formations and on Physical Evidence of Breaks between Paleozoic Systems in Wisconsin," *Trans Wis Acad Sci*, 21 72 90 1924

[8] Ulrich, E O, and Resser, C E, "The Cambrian of the Upper Mississippi Valley, Part I Trilobita, Dikelocepalinae and Osceolinae," *Bulletin of the Public Museum of the City of Milwaukee*, 12 11 1930

closing stage of the Cambrian" In much of both northeastern Wisconsin and northern Michigan no sandstone can be distinguished at this horizon, and the contact is fixed only with difficulty in well logs Heretofore strata of Trempealeau age have undoubtedly been included in the Beekmantown The writer has fixed the upper limit of the Trempealeau at the contact between prevailingly gray, more or less cherty dolomite above and prevailingly red or pink, non-cherty sandy dolomite below Closer determination of this horizon by use of insoluble residues is desirable Glauconite is abundant in the lower part of the Trempealeau and may extend through it and even up into the base of the Lower Magnesian It can be found easily by dissolving the samples in hydrochloric acid The bottom of the Trempealeau is more easily fixed than its top, for it is marked by an abrupt lithologic change to the underlying sandstone The thickness of the Trempealeau along the section here considered seems to vary from 30 to 130 feet This variation may be due in part to inaccurate determination of the top, but it is quite probable that, as the sandstone at the top gives out to the southwest, there is a disconformity between the Beekmantown and the Trempealeau marking the Ordovician-Cambrian boundary

PARTIAL LOG OF WELL OF ESCANABA AND LAKE SUPERIOR RAILROAD, WELLS, MICHIGAN

	Thickness Feet	Depth Feet
Dolomite, pink, much fine sand	20	530
Dolomite, light gray and pink	40	570
Dolomite gray and pink, sandy, glauconitic	5	575
Dolomite, light gray, some pink, sandy, part pyritic	30	605
Total	95	

PARTIAL LOG OF WELL OF MENOMINEE AND MARINETTE LIGHT AND TRACTION CO MENOMINEE, MICHIGAN

	Thickness Feet	Depth Feet
Dolomite, light pink, sandy, glauconitic	9	495
Dolomite, gray, dark blue spots, sandy	5	500
Dolomite, gray, very sandy, pyritic	22	522
Total	36	

PARTIAL LOG OF WELL NO 2 OF SCHOOLCRAFT DEVELOPMENT SYNDICATE, SEUL CHOIX POINT, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, coarse, white	10	1302 5
Sandstone, coarse, white, some green grains, slightly dolomitic	5	1307 5
Sandstone, medium, white	17 5	1325
Sandstone, fine, buff and pink, dolomitic, shale, greenish gray	10	1335
Sandstone, fine, red, dolomitic, shale, greenish gray	12 5	1347 5
Dolomite, buff, sandy, shaly	20	1367 5
Dolomite, dark red to dark buff	5	1372 5
Total	80	

MAZOMANIE SANDSTONE

The strata underlying the Trempealeau formation in eastern Wisconsin are commonly termed "Mazomanie" In Michigan these strata are part of the Munising sandstone The questions of the proper application of the term "Mazomanie" in respect to priority and the relation of the Mazomanie sandstone to the Franconia sandstone farther west need not here be entered upon Suffice it to say that the writer has for some years used the name to cover all the dolomitic sandstone between the base of the Trempealeau and the top of the underlying clean sandstone of the Dresbach The Mazomanie, as thus defined, is characteristically glauconitic, although that mineral is much less abundant in Michigan than it is farther south The thickness of the Mazomanie in the section here described varies from 65 to 140 feet It is not unlikely that certain beds ascribed by Ulrich to his "Devils Lake" formation lie within or at the top of the Mazomanie, or possibly within what is here termed Trempealeau

PARTIAL LOG OF WELL OF MENOMINEE AND MARINETTE LIGHT AND TRACTION CO, MENOMINEE, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, medium to fine, gray, very dolomitic	23	545
Sandstone, very fine, greenish gray, very dolomitic, glauconitic	30	575
Sandstone, medium to coarse, gray, very dolomitic	38	613
Sandstone, medium to coarse, white, clean	4	617
Sandstone, medium, gray, dolomitic	33	650
Sandstone, very fine, gray, very dolomitic	5	655
Sandstone, coarse to medium, gray, dolomitic	3	658
Total to pre-Cambrian	136	

PARTIAL LOG OF WELL OF ESCANABA AND LAKE SUPERIOR RAILROAD, WELLS, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, medium to coarse, light gray dolomitic	30	635
Sandstone, medium light gray, dolomitic	35	670
Total	65	

PARTIAL LOG OF WELL NO 2 OF SCHOOLCRAFT DEVELOPMENT SYNDICATE, SEUL CHOIX POINT, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, white, some dark gray grains	10	1382 5
Sandstone, white, some dark gray shale	7 5	1390
Sandstone coarse, white, slightly dolomitic	2 5	1392 5
Sandstone, coarse, white, dolomitic, shale, dark gray	5	1397 5
Sandstone, medium, white	2 5	1400
Sandstone, coarse, white, dolomitic, shale, dark gray	12 5	1412 5
Sandstone, medium white, slightly dolomitic	47 5	1460
Sandstone, medium, white, considerable gray dolomite	10	1470
Sandstone, medium white, slightly dolomitic	12 5	1482 5
Sandstone, medium, white to gray, slightly dolomitic	17 5	1500
Total	127 5	

DRESBACH SANDSTONE

For some years the writer has used the term "Dresbach" to include all the strata of northeastern Wisconsin which intervene between the highest clean white sandstone and the underlying pre-Cambrian Farther west and south it is possible to separate the top of this sequence as the Dresbach and to call the remainder "Eau Claire" and "Mt Simon" In that region a division is possible because the Eau Claire is shaly and contains many red strata The Mt Simon, which lies next to the pre-Cambrian, is much coarser grained than the Eau Claire In the region under discussion the entire interval is sandstone, and subdivision is impracticable The questions of priority and original application of these names cannot be here considered The thickness of the Dresbach of this section reaches a known maximum of 210 feet This formation is locally absent in northern Michigan

PARTIAL LOG OF WELL OF COLEMAN CANNING CO, COLEMAN WISCONSIN

	Thickness Feet	Depth Feet
Sandstone coarse gray (base of Mazomanie?)	5	260
Sandstone, fine to medium, light gray	55	315
Sandstone medium to coarse white	5	320
Sandstone fine to medium light gray	16	336
Total penetrated	81	

PARTIAL LOG OF WELL OF ESCANABA AND LAKE SUPERIOR RAILROAD, WELLS, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, medium, white	75	745
Sandstone very coarse to medium, white and pink	11	756
Conglomerate pebbles of schist in medium gray sandstone	4	760
Total to pre-Cambrian	90	

PARTIAL LOG OF WELL NO 2 OF SCHOOLCRAFT DEVELOPMENT SYNDICATE SEUL CHOIX POINT, MICHIGAN

	Thickness Feet	Depth Feet
Sandstone, coarse, white	17 5	1517 5
Sandstone, pink, dolomitic	2 5	1520
Sandstone, medium, white	5	1525
Sandstone, medium pink, dolomitic	2 5	1527 5
Sandstone, medium, pink	32 5	1560
Sandstone, medium, cream to pink, slightly dolomitic	52 5	1612 5
Sandstone, medium gray, shale, gray, dolomitic	12 5	1625
Sandstone, fine, gray, slightly dolomitic	85	1710
Total penetrated	210	

JACOBSVILLE SANDSTONE

The term "Jacobsville" as applied to sandstone includes all of Irving's "Eastern Sandstone" shown on his map as Division I of the Paleozoic formations [a] It is predominantly a red sandstone, for the most part quite arkosic, and filled with layers both of conglomerate and of red micaceous sandy shale Stratification is extremely irregular It is probably equivalent in age to the upper part of Irving's "Western Sandstone" of Wisconsin, a group which the writer termed "Bayfield" In 1912 the writer decided that the

[a] Irving, *op cit*, Plate XXVIII, after p 410

Bayfield sandstones are non-marine, a conclusion which has stood the test of over twenty years Irving believed — and his conclusion has been accepted by most geologists down to the present day — that the red Jacobsville sandstones are the conformable downward extension of the light-colored Munising sandstone It must be realized that this conclusion was reached long before the dawn of modern knowledge of sedimentation and that disconformities between horizontal beds were then unrecognized In the light of present-day science a restudy of the question in the vicinity of Munising, where the contact is exposed, might disclose a vast hiatus involving the great pre-Cambrian peneplain Unfortunately, the available well logs are not sufficient to add much to the solution of this important question Two very poor logs in the present section indicate red feldspathic sandstone of a type foreign to the recognized Upper Cambrian If the correlation of these beds which is suggested on the section as Jacobsville is correct, it would serve to strengthen the hypothesis of a disconformity In this connection it is necessary to note that at Limestone Mountain [10] the red sandstones are overlain not by Munising sandstone, but by Black River dolomite The same condition is also true near Sault Sainte Marie [11] These facts suggest a profound hiatus, although it might be urged that it may not be the base of the Cambrian, but rather the sub-St Peter unconformity

CONCLUSIONS

In the present state of knowledge the following facts have been established

1 No St Peter sandstone can be recognized in northern Michigan

2 The Beekmantown formation includes several sandstone members which should not be confused with either the St Peter or the Jordan sandstones

3 The Trenton (Black River) formation is disconformable on the Beekmantown, and study of insoluble residues is needed to fix the plane of division more accurately than has been done heretofore

[10] Case, E C, and Robinson, W I, "The Geology of Limestone Mountain and Sherman Hill in Houghton County, Michigan," *Mich Geol and Biol Surv* Publ 18, Geol Ser 15, pp 165 181 1915

[11] Lane and Seaman, *op cit*, p 89

4 The Trempealeau formation, as defined at present in Wisconsin, extends into Michigan and has formerly been included with the Beekmantown, it can be discriminated by use of insoluble residues and by its red colors

5 The Trempealeau is probably disconformable below the redefined Beekmantown (Lower Magnesian), for the Jordan sandstone is missing throughout much of northern Michigan

6 The Mazomanie and Dresbach sandstones as now defined in northeastern Wisconsin extend into northern Michigan and form the Munising sandstone

7 It seems probable that the Jacobsville non-marine sandstone is separated from the marine Munising sandstone by a profound disconformity which marks the top of the pre-Cambrian, but final conclusions on this point await further field studies If this suggestion proves correct we would have to return to the interpretation of Houghton,[12] made in 1841, that "this sandstone [Munising] rests unconformably upon the red sandstone [Jacobsville], the former dipping gently to the south or southeast, while the latter dips very considerably to the north or northwest " [13]

University of Wisconsin

[12] Houghton, Douglass, *Geological Reports of Douglass Houghton, First State Geologist of Michigan*, 1837–1845, (Michigan Historical Commission, Lansing), p 499 1928

[13] "A short distance northwest from Munising and on Grand Island are excellent exposures of conglomerate, up to 10 feet thick, composed of well rounded quartz pebbles principally On Grand Island the exposure in the cliffs shows that this conglomerate lies between an upper cream to buff sandstone and a lower red and white mottled sandstone The beds below the conglomerate dip gently in a northward direction and close above it the conglomerate dips gently in a south ward direction, so that at the south end of Grand Island the conglomerate is at water level, while at the northern end it is 125 feet or more above water level There is no basis for an assured correlation of the lower series, but my belief from its lithologic character is that it is the same as the Jacobsville The upper sandstone grades upward into fossil-bearing beds, so that we know they are Paleozoic " — W O Hotchkiss, personal communication, March 27, 1933

THE CENSORSHIP OF LENGLET DU FRESNOY'S *MÉTHODE POUR ÉTUDIER L'HISTOIRE*, 1729

MANSON MILNER BRIEN

"ALL of us are curious and we penetrate with pleasure into what one desires to hide from us"[1] The words of this eighteenth-century critic remain substantially true today, and it is with an interest born of curiosity as well as a desire for knowledge that the two-hundred-year-old veil of the censorship is lifted from Abbé Lenglet du Fresnoy's *Méthode pour étudier l'histoire*[2] This work and its *Supplément* passed through thirteen editions between 1713 and 1772, and was also translated into English and Italian These represent several more printings than the justly acclaimed *Dictionnaire* of Pierre Bayle, which is frequently termed the "Bible" of the eighteenth century Moreover, the *Méthode* was one of the few widely influential books which submitted in every respect to the rigorous publishing requirements of the French government These two factors doubly enhance the value of an inquiry into the suppressed pages On one hand, these pages allow a glimpse of the author's unrestricted ideas and provide a detailed view of the conditions under which he wrote, and, on the other, they offer an unusual reverse of the common treatment accorded eighteenth-century thought They spread before us not the influence of the intellectual world upon the government, but the direct influence of the government upon the realm of scholarly endeavor In them the exact trend of the censorship is disclosed, together with its primary effect on the author and its consequent results upon the reading public

Today the word "censorship" is held in opprobrium Our lib-

[1] Père Bougeant, in the review of *L'Histoire justifiée contre les Romans* *Journal de Trévoux*, July, 1735, p 1210

[2] Lenglet du Fresnoy, *Méthode pour étudier l'histoire* (Pierre Gandouin, Paris, 1729), 4 vols., gr in-4° For a short biography of Abbé Lenglet and the place of the *Méthode* among his extensive writings see Manson Milner Brien, "Lenglet du Fresnoy A Biography, *Pap Mich Acad Sci*, *Arts and Letters*, 18 (1932) 457–478. 1933

erty of the press is so sacred a right that it is hard to imagine a thorough inspection of all published and written material except under the stringent necessities of war Yet this is exactly what confronted the eighteenth-century French historian The censor's approval was obligatory for works of every sort Even scientific and medical books were very carefully scrutinised This system demanded a highly complex, well-organised machine to handle the enormous amount of detail Nominally the supreme authority was vested in the *Garde des sçeaux*, who worked chiefly through the lieutenant-general of police, who had beneath him inspectors to carry out his orders Dependent likewise upon the *Garde des sçeaux* were the censors themselves They were classified according to the type of books they preferred to examine Contrary to expectation, their lot was not at all easy Every page of a book submitted to them had to be read, initialed, and returned with a résumé of the work itself which indicated the reasons for any required changes Held up to ridicule by the writers if they erred too much on the side of prudence, the censors themselves were liable to imprisonment if they failed in their duties [3] Consequently, the fate of the author in the censor's hands frequently depended upon the conditions of the moment Such, briefly, was the system which confronted Lenglet du Fresnoy when he was preparing to publish the fifth edition of his *Méthode pour étudier l'histoire*

In May, 1729, the *Journal des sçavans* announced the distribution of the *Méthode* in these precise terms "On distribue actuellement aux souscripteurs la Méthode pour étudier l'histoire par M Lenglet du Fresnoy" [4] This fifth printing of Lenglet's work was so rearranged, augmented, and corrected that today it would be designated as the author's definitive edition The use of the word *actuellement* in the announcement appears to imply more than the usual meaning Indeed, the delivery of the *Méthode* had been long delayed From the first opening of the lists to subscribers in March, 1728,[5] and the notice of the commencement of the printing in April, 1728,[6] to the final delivery in May, 1729, the progress of the book

[3] Green, Frederick Charles, *Eighteenth Century France* (J M Dent and Sons, London, 1929) The last essay, "The Libraries and the Censorship," is valuable and interesting

[4] *Journal des sçavans*, May, 1729, p 947 "Nouvelles littéraires de Paris"

[5] *Ibid*, March, 1728, pp 573–576 "Nouvelles littéraires"

[6] *Ibid*, April, 1728, p 765 "Nouvelles littéraires"

had been fraught with trouble There were difficulties with the government because the *Méthode* had apparently been illegally subscribed,[7] disagreements between the publishers followed, which ended by La Veuve Coustelier's complete withdrawal from the enterprise,[8] and finally the censor arbitrarily exercised his power to command the insertion of one hundred and forty-six *cartons* at the last moment before the work left the press[9] The editors of the *Journal des sçavans* appeared to recognize, then, Lenglet's efforts, and it was in a sense of acknowledging the difficulties overcome that they employed the word *actuellement*

Lenglet's early biographer, Michault, sarcastically remarked that "the abundance of cartons lets it be seen how the minister honored this work with his attention"[10] Before Lenglet received those few coveted lines of approbation, "J'ay lû par ordre de Monseigneur le garde des Sçeaux, un ouvrage intitulé *Méthode pour étudier l'histoire* par M l'abbé Lenglet du Fresnoy, et il m'a paru digne de tout l'empressement que le public témoigne depuis longtems pour l'avoir Fait à Paris le 18 avril, 1729 — Gros de Boze,"[11] the *Méthode* had been subjected by the undersigned Gros de Boze to an infinite number of changes and deletions[12] Michault and De Bure were one in stating that the cartons of the 1729 *Méthode* were enough to form a rather thick volume in quarto[13] These cartons were sold separately at an extremely high price and were still avidly sought by collectors as late as 1761[14] The censor, Claude Gros de Boze, secretary to the Royal Academy of Inscriptions and Belles-Lettres, who became *Inspecteur du Libraire* in 1745, was somewhat of a scholar, a book collector, and a man of letters He cannot be blamed for conscientiously trying to do his duty and perhaps may be commended for attempting to shield Lenglet in the places where his advanced thought would have brought much trouble Owing to Gros de Boze's diligence a complete check of the censored pages has been preserved till today

[7] *Journal de Trévoux*, November 1729, p 1987, Lenglet, *op cit*, Vol I Épitre [8] Lenglet *op cit* Vol. IV Privilège

[9] Michault, J B, *Mémoires pour servir à l histoire de la vie et des ouvrages de Monsieur l'abbé Lenglet du Fresnoy* (Paris and London 1761), p 77

[10] *Ibid* [11] Lenglet, *op cit*, Vol IV Approbation.

[12] *Journal de Trévoux*, November, 1729, p 1988

[13] Michault, *loc cit*, De Bure, Guillaume, fils aîné, *Catalogue des livres de feu M le Duc de la Vallière* (De Bure, fils aîné, Paris, 1783), I, Part 3, 2

[14] Michault, *loc cit*

Gros de Boze had a magnificent copy of the *Méthode pour étudier l'histoire* printed for himself It was hand-illuminated and incomparably better than all others, although not entirely free from considerable faults [15] Only two copies of the *Méthode* are said to have escaped the censor's corrections, that of Gros de Boze and the one which belonged to the Duc de la Vallière [16] Concerning the Boze copy the *Mercure de France* wrote "Cet exemplaire est singulier en ce qu'il n'a point de cartons, et que l'on trouve à la fin un cahier de remarques sur les changemens faits par ordre du Magistrat " [17] Upon the death of Gros de Boze his copy passed into the hands of Monsieur Camus de Limar, who in turn allowed Guillaume de Bure to use the censor's own notes when De Bure was printing his catalog of the library of the late Duc de la Vallière In this catalog De Bure reproduced the notes in their entirety,[18] and thus the censor's own detailed account of the suppressed lines has been made available

The preservation of several cartons themselves was due to the activity of August Beyer, who collected rare examples of surreptitious printing In 1734 Beyer published a curious volume which contained many cartons from the 1729 *Méthode* [19] It has often been believed that Beyer published the suppressed pages completely A careful check, however, has disclosed that Beyer's work contains only the cartons from the first volume and among these, only the more important passages Many of the lines printed by Beyer were not listed in the notes of Gros de Boze This leads to the supposition that Lenglet realized that his skepticism and disbelief would cause serious consequences, hence he was careful to lay aside the most objectionable phrases before the manuscript went to the censor

This assumption is strengthened by De Bure's statement that eighteen changes made by Lenglet himself were included among the cartons [20] De Bure, however, is very incorrect in his estimate of Lenglet's personal changes Volume one of the *Méthode* contains sixty-six starred pages indicating to the binder that they were to replace the ordinary pagination and marking for the public the

[15] Michault, *op cit*, p 74

[16] De Bure, *loc cit*

[17] November, 1753, p 133

[18] De Bure, *op cit*, I, Part 3, 1–14.

[19] Beyer, August, *Memoriae historico-criticae librorum rariorum* (Fred Hekel, Dresden and Leipsig, 1734), pp 166–206

[20] De Bure, *op cit*, pp 2–3.

passages touched by the censor Of these sixty-six pages only twenty are listed by Gros de Boze, which makes it appear that Lenglet caused forty-six changes (Four pages were touched by both Lenglet and the censor) In volume two the same case reoccurs There are fifty-four starred pages, only ten of which are indicated by the censor Thus in the two quarto volumes of text we find only thirty cartons ordered by the magistrate On the other hand, ninety changes are due to Lenglet alone Such acts would be very characteristic of Lenglet Inasmuch as he always attempted to make his literary efforts pay, profit was among his primary objectives It is not unlikely, then, that Lenglet placed among the cartons other passages more liable to governmental objection, which the censor did not even glimpse These would increase the collector's desire for the forbidden lines and bring about a correspondingly higher price, resulting in considerable gain to both Lenglet and his publisher The fact that the changes by both the censor and Lenglet are marked in the text makes it clear beyond a doubt that the latter desired to sell not only the lines suppressed by official command, but also his own liberal passages, which he dared not risk submitting to the censor

It is apparent that Lenglet and his publisher did not bother to make cartons for a few words, a phrase or a line, but were content to print and sell only the more prominent articles which the censor modified in thought and content The study of the censor's own deletions must necessarily disregard Lenglet's personal changes For convenience in analysis alone the magistrate's cartons may be divided into the following classes political, religious, personal, general, scholarly, and moral, so named because the reason for each suppression falls under one of these general headings Such categories are purely arbitrary, but extremely suitable for the procedure of the censorship

The number of cartons under each heading reveals in a striking manner the direction of the censor's efforts Out of one hundred and forty-six cartons sixty-one are strictly political, whereas only two are moral in the modern sense This more than anything else demonstrates the tendency of the government to use the censorship mainly as a political check The accompanying table points out the various gradations of the *Méthode's* cartons [21]

[21] Figures are based on the censor's list in De Bure, *op cit*, I, Part 3, 3–14

Class	*Cartons*	*Percentage*
Political	61	42
Religious	30	20
Personal	29	20
General	14	10
Scholarly	10	7
Moral	2	1

The table also serves to indicate the difficulties which beset the eighteenth-century historian His thought was supervised on every side, and nothing which was too radical or too forceful escaped censure

Out of the sixty-one political cartons thirty-seven were suppressions and twenty-four represented changes in Lenglet's thought, or in the manner in which it was expressed As required by law, Gros de Boze noted the reasons for his acts Twenty-three changes were made because the phrase was directly or indirectly offensive to royalty Nor was Lenglet accustomed to spare the ministers and corrupt government Such remarks as, "on feroit de gros volumes de remonstrances, si à chaque nature de dissipation et mauvaise manoeuvre des commis aux finances, on faisoit des remonstrances au Roi," [32] were ruled out Insinuated criticism of feminine activity in the affairs of the kingdom, as, "Peut-être a-t-il voulu nous instruire d'un usage qui n'a que trop paru dans la suite de tous les gouvernemens, où les femmes n'ont pas eu moins de part aux grands évenemens que les plus grands ministres," [33] likewise failed to receive approval Since the *Méthode* was published at a time when the policy of France, directed by Cardinal Fleury, sought an established peace, distinct efforts were made to remove anything, however minute, which might disturb the harmonious relations with other countries Three cartons are sufficient to show that the eye of the government watched all references to foreign nations wherein France had some interest A remark about England, "Il n'y a pas de bonne cause en Angleterre qui ne trouve des adversaires comme elle trouve des protecteurs," [34] was dropped The precarious diplo-

[32] De Bure, *op cit*, I, Part 3, 10, Lenglet, *op cit*, 4 137

[33] Beyer, *op cit.*, p 202 From Lenglet's manuscript of the *Utilité des Romans*, quoted and suppressed in the *Méthode pour étudier l'histoire*, 1729, and finally published under the name of Gordon de Percel as the *De l'usage des Romans* (Amsterdam, 1734)

[34] De Bure, *op cit*, I, Part 3, 6, Lenglet, *op cit.* 2 536

matic question of the Empire and Italy could not be discussed, and Lenglet's opinion that "on aura bien de la peine à faire revivre les droits des Empereurs sur l'Italie et de les en faire déclarer Rois"[25] was completely deleted Nor would the government even risk giving offense to little Portugal by a few lines which read, "Peu s'en faut que la description ne soit plus grande que le royaume, il faut de la modération en tout"[26] Joined to the major causes for removal, disrespect to royalty, ministers, and foreign governments, were phrases offensive to the courts and common intelligence, together with a few arbitrary changes by the censor These few short passages, which today would be of no apparent harm, display the great weight which the ministry attached to every remark, no matter how insignificant, that might in any way reflect upon its masters, its personnel, and its policy Lenglet did not suffer alone in this respect

Although Lenglet was a priest and a *licencié* of the Sorbonne, his cloth did not protect his remarks on religion and the Church In this field Gros de Boze censored thirty cartons, seventeen of which were suppressed outright and thirteen modified The majority of the cases concerned the Church in general, and all such remarks as, "ce n'étoit point là s'y prendre bien que de voler les Protestants pour se faire Catholiques, car l'église catholique n'a que faire de voleurs, il n'y en a déjà que trop dans son sein,"[27] or, "Quoique l'ouvrage de M Bianchini ne soit pas propre à être lu de tous ceux qui étudient l'histoire, il fait paroître plus d'érudition, qu'il ne s'en trouve dans des Prélats romains,"[28] were removed Minute instances of pure skepticism were found and altered Lenglet's phrase, "Les trois enfans de Noé sont la source commune de toute l'humanité, au moins le devons-nous croire ainsi,"[29] appeared in the *Méthode* without the words following the semicolon[30] All lines where there was a possible chance of giving offense to the clergy were completely deleted In regard to Nicolas de Buzenval and François de Beauvilliers, eminent bishops, Lenglet's slightly

[25] De Bure, *op cit*, I Part 3, 8, Lenglet, *op cit*, 3 346
[26] De Bure, *op cit* I Part 3, 13 Lenglet *op cit*, 4 357
[27] De Bure, *op cit*, I, Part 3, 8, Lenglet, *op cit*, 3 299
[28] Beyer, *op cit*, p 169
[29] *Ibid*, p 176
[30] Lenglet was perpetually at war with his censors and reëstablished every suppressed line that he could This particular example is found completely printed in *Méthode pour étudier la géographie* (De Bure l'aîné, Paris, 1742), 7 12

humorous comments were dropped "Grand et saint Evêque," he wrote about M de Buzenval, "on n'en trouve plus de cette trempe",[31] and in regard to M de Beauvilliers he observed, "Ce sage prélat a quitté son Evêché parce qu'il s'ennuyoit de conduire de grands troupeaux, il se réduit, tout-au-plus à une brébis ou deux "[32] What we would call today a fair but obvious criticism of the Bible was suppressed by Gros de Boze because of its possible influence on the readers, "L'écriture sainte que nous regardons comme la source la plus ancienne, je dirai même la plus certaine de l'histoire est en défaut sur cet article [sources for all ancient history] Parle-t-elle de la création de l'Homme, parle-t-elle de la formation ou du rétablissement d'un peuple, c'est toujours par rapport aux juifs "[33] Such passages widely circulated in the *Méthode* would have had a far-reaching effect upon the students of history in the early years of the eighteenth century But any result they might have had was absolutely stifled by the censorship Nothing, indeed, was too small to escape the censor's eye Even the word *infâme*, which Lenglet used to describe the death of Jean Huss, was removed Despite the fact that Lenglet was a churchman in good standing and might have been expected to take some slight liberty with those of his own cloth, everything the least bit skeptical, or the least bit offensive to religion, dogma, popes, bishops, monks, and the monarchy, was either modified or removed

Lenglet was well known among his contemporaries for his frankness and for his outspoken criticism of both men and books In this respect Gros de Boze appeared to have no leniency, especially when his opinion differed materially from Lenglet's Personalities, rumors about authors, all which might harmfully reflect on a man, were taken out Under this personal heading there was a total of twenty-nine cartons, one fewer than for the highly important subject of religion Twenty-four remarks were completely deleted, a greater number than for any other class except the political, whereas only five were altered Some of the suppressed passages would be regarded today as verging upon libel, for example "Le père Hardouin qui n'estime que ses propres ouvrages est fortement accusé

[31] De Bure, *op cit*, I, Part 3, 11, Lenglet, *Méthode pour étudier l'histoire*, 4 189

[32] De Bure, *op cit*, I, Part 3, 11, Lenglet, *op cit*, 4 189

[33] Beyer, *op cit*, p 170

par ses confrères d'avoir fait disparoître le manuscrit de l'Asie et de l'Afrique qui restoient à publier de ces *Paralleles* "[34] Lenglet's observation that "M de Lisle auroit dû, cependant, par reconnoissance faire sçavoir au public qu'il étoit redevable de ses plus belles observations au Père du Halde, Jésuite mais peut-être que l'envie de paroître auteur original a empêché M de Lisle d'être auteur équitable et reconnoissant,"[35] was less serious It was perhaps justified in regard to an author who took care not to reveal his sources, nevertheless the magistrate dropped it Even Lenglet's sharp comments, such as "aspirer encore à celle de mauvais auteur, c'est un titre de trop,"[36] found their way into the censor's scrapbook Unlike Lenglet, who was rarely backward in seeking a quarrel with the Jesuits, Gros de Boze seemed afraid of their organ, the *Journal de Trévoux* He removed entirely Lenglet's remarks about two Jesuit authors, the Pères Catrou and Rouillé, even though Lenglet's criticism, couched in sharp language, of their manner of writing, use of material, and notes was extremely well founded[37] As the suppressions in the category of personalities imply, nineteen cartons were considered injurious to books and authors, four were detrimental to the character of monks and to religion, and six were arbitrary changes made by the censor because his ideas were not in accord with those of Lenglet

The broad term "general," covers a multitude of Lenglet's sins in the eyes of Gros de Boze This classification, though not so large as those of politics, religion, and personalities, accounts for ten per cent of the cartons, fourteen in all By the magistrate's command there were nine suppressions and five changes The following comment, "ce n'est pas que le livre fût assez bon ni assez mauvais pour le faire brûler, car c'en sont les deux motifs, mais il y avoit des choses qui déplaisoient,"[38] reflected directly upon the conduct of the censorship and so was obliterated Also a caustic remark on the press, "Les Mercures françois ont repris dans ces derniers temps l'estime qu'on leur avoit refusée auparavant, tant pour le détail des faits que pour la nature des actes qu'ils contiennent,"[39] underwent

[34] *Ibid*, p 168 The *Paralleles* mentioned was written by Philip Briet, *Parallela geographiae*, 3 vols, 4° (Paris, 1648–49)
[35] *Ibid*, p 169
[36] De Bure, *op cit*, I, Part 3, 9
[37] See Beyer, *op cit*, pp 200–201
[38] De Bure, *op cit*, I, Part 3, 10, Lenglet, *op cit*, 4 126
[39] Beyer, *op cit.*, p 170

the same fate "C'est un morceau très précieux et qui a été volé au dépôt des affaires étrangères qui est au Louvre," [40] was a passage capable of giving offense to ministers and the government It, too, was taken out by the censor A majority of cartons in this category, seven, were made because they displeased Gros de Boze, three gave offense to Royalty and nobility, the reasons given for the remainder were skepticism and Lenglet's too free statements about commerce Thus it is quite evident that not one province of the author's thought was unexamined by the government

The last two categories, scholarly and moral, account for eight per cent of the total number of cartons In the former class there were ten, five suppressed and five modified The reasons for these changes were equally divided Gros de Boze believed that five of Lenglet's passages were definitely harmful to established reputations, the other five comments were cartoned because the censor disagreed with Lenglet's judgments Only two cartons, or one per cent, can be classified as removals on moral grounds Both of these the magistrate considered ironical and skeptical, and both were suppressed [41]

Perhaps the most surprising point in this study of the censorship is the apparently complete reversal of its purpose Today moral reasons are the only cause for the existence of the censor in times of peace When Lenglet wrote, however, morality accounted for only one per cent of the censor's attention, yet Lenglet has been regarded as displaying in his writings "no more morality than a cat" It would appear that the censor was deliberately indifferent to the moral questions involved This, however, is not strictly true The *Méthode* rarely deals with moral factors, and even less frequently descends to vulgarity Only twice did Lenglet exceed the limits of eighteenth-century propriety, and in both instances he was checked by the censor But with his usual temerity he reprinted both passages in the *De l'usage des Romans* five years later This

[40] De Bure, *op cit*, I, Part 3, 14, Lenglet, *op cit*, 4 458

[41] The available copies of the *Méthode pour étudier l'histoire* are laws unto themselves for the number of cartons bound in each one The copy possessed by the University of Michigan contains a great many, my own copy, formerly the property of the Bibliothèque des Chapelles, has several, as does the copy in the Library of Congress The number of cartons included in each copy probably depended upon the desire of the original purchaser and the price he was willing to pay

work appeared secretly The astonishing lack of criticism on moral grounds may be more accurately laid to the fact that books considered vulgar, immoral, and licentious never appeared before a censor, but were printed either in foreign countries or secretly in France, without *approbation* or *privilège*

A great deal of pettiness is found, especially in the censor's treatment of minor points Arbitrary changes in the use of words, in judgments, and in opinions are very evident in the general and scholarly classes Indeed, twelve per cent of all the cartons have as a *raison d'être* the magistrate's expressed disagreement with the author's statement [42] This alone reveals the tremendous power of the censor to change the style, ideas, and conclusions of an author In the case of Gros de Boze, it is only fair to remember that he was a scholar and a man of letters, consequently, the *Méthode* did not greatly suffer But such power in the hands of an indifferent and uneducated man became immediately dangerous, and many a work was unquestionably harmed by the ignorant abuse of the censor's privileges

Though in the present case the censor did not destroy the individuality of the *Méthode*, nevertheless he made certain distinctly retrograde changes in regard to Lenglet's historical thought The tone of Lenglet's writing in the censored cartons was markedly skeptical and ironical He made statements that no churchman could freely make, and he pushed his historical point of view to the utmost limits permitted by the development of Cartesian philosophy

Lenglet's method and his treatment of historical problems were direct outgrowths of the Cartesian search for truth, which, carried to its greatest extent, could only result in two points of view, rationalism and what we now term the scientific method Both sought the truth, the former by the attempt to build up a factual explanation from an a priori conclusion, and the latter by the amassing of many small truths from which the conclusion was formulated Almost alone among eighteenth-century scholars Lenglet du Fresnoy adopted the latter method and clung to it until he was overwhelmed by the widening tide of rationalistic thought and stifled by the censorship

The practical demonstration of Lenglet's then novel method of

[42] Arbitrary changes 'Personal' 6, General, 7, Scholarly, 5

approach suffered most at the hands of the censor Gros de Boze had no quarrel with Lenglet's theories, but he did object in the name of church and state to Lenglet's examples Unfortunately, Lenglet chose to work out his point of view using as material delicate questions of dogma and pertinent Biblical statements Foremost among these passages was the demonstration that the Flood was not universal and could not have been Here his proof was built up along strictly modern lines, culminating with the heretical conclusion, "Le déluge n'a pas été universel" [43] Gros de Boze eliminated without mercy every line of such reasoning, and without proof Lenglet's theory was valueless He was left an emasculated *Méthode* which, although containing enough skeptical ideas and rationalistic expositions to arouse clerical wrath,[44] failed to present a definite practical demonstration of his manner of solving a historical problem It can be doubted whether Gros de Boze realized the general destructiveness of Lenglet's theory in regard to the prevailing historical conceptions All that was necessary to cause the censor to act was the evident knowledge that Lenglet was apparently attacking the Church and dogma The attack was suppressed, and with it the theory of the factual approach, which was not to regain its advocates until more than a century had passed

The Marquis d'Argens offers a glimpse of the uncensored *Méthode's* possible influence "Le père du Halde," writes Argens, "étoit Jésuite, par conséquent obligé à certains ménagemens D'ailleurs s'il se fût expliqué aussi sincèrement que l'abbé Lenglet, on eut fait supprimer de son livre, ce qu'il auroit dit à ce sujet, comme on l'a fait ôter de l'abbé Lenglet" [45] Argens regards Lenglet as a true scholar and a true philosopher, and in his pseudo-philosophical-historical discussion of the Flood Argens follows Lenglet exactly, appearing to admire his sincerity and capable treatment Although it is difficult and practically impossible to estimate the effect of an uncensored *Méthode* upon a reading and thinking public, it is safe to state that its widespread influence would have been even more extensive if the censor had not limited Lenglet's most advanced theories to the few wealthy collectors who could afford the cartons

[43] These passages are too long for reproduction here, see Beyer, *op cit*, pp 170–176, 186–195

[44] Brien, *op cit*, p 467, *Journal de Trévoux*, November, 1729, p 1987

[45] Le Marquis d Argens, *La Philosophie de bon-sens* (Paupie, La Haye, 1746) 1 49, note

That Abbé Lenglet's *Méthode pour étudier l'histoire* suffered at the hands of the censor is beyond all question of doubt The last minute changes ordered before it left the press were inconvenient, but not important The suppression of Lenglet's frequently caustic personal remarks may have rendered him angry, but they brought forth no public comment The top-heavy number of political and religious cartons as opposed to the few made on moral grounds is not unexpected in a government which sought to preserve itself from criticism Indeed, all dwindle into insignificance beside the fact that one brain, acting as a government agent, had the unwitting power to change the course of historical thought for more than a century [46]

Alfred Holbrook College
Lebanon, Ohio

[46] Summary of the censor's changes

	Cartons	*Suppressions*	*Changes*	*Percentage*	*Chief reasons*
Political	61	36	25	42	Offensive to royalty, governments foreign countries, and religion
Religious	30	17	13	20	Offensive to Church, Bible dogma, popes, monks and religion, skeptical
Personal	29	24	5	20	Offensive to religion and the censor or injurious to an author and his works
General	14	9	5	10	Offensive to royalty and in disagreement with censor
Scholarly	10	5	5	7	Harmful to reputation and displeasing to censor
Moral	2	2	0	1	Ironical and offensive to censor

THE MICHIGAN CONSTITUTION OF 1835

HAROLD M DORR

IN URGING upon the inhabitants of the Territory of Michigan the desirability of framing a constitution and state government the proponents of immediate admission advised the exercise of a power that they sincerely believed had been reserved to the people by the Ordinance of 1787 As an incentive to settlement within the Territory, the fifth article of the Ordinance held forth the promise that "whenever any of the said States shall have sixty thousand free inhabitants therein, such State shall be admitted by its delegates, into the Congress of the United States, on an equal footing with the original States, in all respects whatever "[1] In conformity with the provisions of the original deeds of cession, these articles of the Ordinance had been designated as a solemn compact, irrevocable except "by common consent" The people of Michigan had never consented to the repeal of this compact, and it was now claimed that, since her population exceeded "sixty thousand free inhabitants," the Territory, upon the adoption of a state constitution, was entitled to exercise her right to admission[2] Nor were these arguments totally unsubstantiated in fact

The question had first been raised in Congress as early as 1796 When the population of the Territory of Tennessee had been ascertained to exceed "sixty thousand free inhabitants," a constitution was adopted and the Territory demanded admission to the Union as a right — "a *right* which Congress could not deny" — guaranteed by the original deed of cession and the Ordinance The ensuing debates in the House of Representatives presented a division of opinion among the members on the question The proposition that "Territories of the United States could, at their own mere will and pleasure, and without the declared consent of Congress, erect them-

[1] *United States Statutes*, I 52

[2] Governor Mason declared that "the only discretion left for Congress to exercise is to determine, that our constitution is 'Republican "— *Messages of the Governors of Michigan* (edited by G N Fuller, Lansing 1925), I 126

selves into a separate and independent state," aroused considerable resentment in the House [3] However, the merits of the particular case overcame the opposition and Tennessee was reluctantly "declared to be one of the United States of America" [4]

Governor Mason, who had familiarized himself with the circumstances under which Tennessee had been admitted, became the principal proponent of the theory in the Territory, and argued that the inhabitants of Michigan should likewise assert their rights and demand admission without awaiting the passage of an enabling act by Congress [5]

Finding justification for its action either in the force of Mason's argument or in the belief that a Congressional enabling act would be considered retroactive, the legislative council proceeded to authorize the inhabitants of the Territory to choose delegates to frame a constitution for the proposed state of Michigan [6]

In authorizing the election of delegates to form a constitutional convention the council acted upon its own authority and sought no official mandate from the people beyond the unconvincing results

[3] *Benton s Abridgement of the Debates of Congress* (New York, 1857), I 754–759

[4] *United States Statutes*, I 491–492 "The claims of Tennessee to admission, based upon the provisions of the Ordinance of 1787 did not receive from that body [Congress] a ready or unquestioned assent ' — J A Jameson, *The Constitutional Convention Its History, Powers, and Mode of Procedure* (New York, 1867), pp 159–167 The question was again raised, in a somewhat different form, when Congress threatened to interfere with the convening of the first Ohio convention See Jacob Burnet, *Notes on the Early Settlement of the North-Western Territory* (Cincinnati, 1847), pp 497 501 See also *Benton s Abridgement*, pp 648–653

[5] *Messages of the Governors*, pp 125–128, 129–138, 158–176 For further discussion of the compact theory of the Ordinance see T M Cooley, *Michigan, A History of Governments* (American Commonwealth Series, Boston, 1905), pp 211–220, J V Campbell, *Outlines of the Political History of Michigan* (Detroit, 1876), pp 449–462, W C Haight, "The Binding Effect of the Ordinance of 1787," *Publications of the Michigan Political Science Association*, Vol II, No 8 (Sept, 1897) The Supreme Court of the United States declared that the Constitution superseded the Ordinance of 1787, and that such provisions of the Ordinance as were not inconsistent with the Constitution remained in force only so far as they were validated by acts of Congress or state laws See *Strader* vs *Graham*, 10 How 81

[6] Mason was persistent in his contention that Congressional action was unnecessary "The legislative council, in obedience to public sentiment, and by virtue of an authority derived from the irrepealable ordinance of seventeen hundred eighty-seven, passed 'an act to enable the people of Michigan to form a constitution and state government'" — *Messages of the Governors* (Feb 1, 1836), p 160

of the election of 1832. This presumption of power gave rise to a bitter controversy which, though partisan in nature, was carried to the floor of the convention. The Conservatives conceded that the power to form a constitution rested with the people, but by what authority, they argued, could the council presume to empower the people to exercise a power vested exclusively in them? Additional embarrassments were averted in that the council, after authorizing the election of delegates and fixing the date of the convention, did not presume to go farther and instruct or restrict it in the performance of its duties.

This absence of legislative restriction was undoubtedly the result of oversight and expediency, but proved fortunate in consequence, and accommodated the convention to the theory of popular sovereignty expounded by the Mason group. When questions pertaining to the legal position of the convention and the scope and extent of its powers arose, the convention was at liberty to consider itself convened in response to popular authority, derived directly from the Ordinance of 1787. Consequently, the Act of January 26, 1835,[7] in spite of its wording, was conveniently interpreted as recommendatory rather than mandatory. In acting favorably upon the recommendation the people discharged the council from further responsibility and invested the convention with complete authority.[8]

Untrammeled by Congressional or other legislative restraints, the convention regarded itself responsible directly to the people, and, once it was convened, was free to define its own jurisdiction. "Such a body," says Professor Holcombe, "is a revolutionary rather than a constitutional convention, and the extent of its powers would apparently be determined by itself, subject only to the limits which the people in their capacity of ultimate sovereign may be able to impose."[9] A semblance of constitutional regularity may be obtained for the Michigan convention by regarding the act of admission as retroactive in effect.

This legal position of the convention was not clearly fixed in the

[7] The Statehood Act. *Michigan Territorial Laws* III. 1356–1359.

[8] Professor A. N. Holcombe, *State Government in the United States*, 3d ed. (New York, 1931), p. 131, advanced the following theory: "The calling of a convention, therefore, without a vote of the people must be regarded as an abdication of power by the regular legislature in favor of an extra-constitutional body."

[9] *Op. cit.*, p. 131.

minds of the delegates when they assembled in Detroit on the eleventh day of May, in fact, the sovereign character of the assembly became disclosed only as the convention was faced with practical difficulties in the performance of its duties Through a series of final determinations on issues of necessity or expediency, it defined its own jurisdiction and established its responsibility to the people John Norvell and William Woodbridge, representing opposing interests, and bitter political enemies were agreed that the convention was basically independent of legislative control [10] "It is not pretended," Woodbridge is reported to have said, "that the Legislative Council had any authority to pass a law calling a convention of this sort , it is entirely recommendatory and could not trammel or control this body by its provisions, and this convention is left free to pursue that course which truth and justice may vindicate " [11]

The convention, slowly outlining this unlimited jurisdiction as it progressed, drew upon its own authority to perfect its organization and adopt its agenda It fixed the compensation of its members and officials, [12] it appropriated money to defray the expense of "fitting up this hall for the accommodation of this convention," [13] and to compensate persons for the use of committee rooms [14] Again, it ordered the remodeling of the Capitol and authorized the first legislature under the state government to appropriate the necessary money [15] The convention deviated even farther from its primary purpose in recommending a special election for Jackson County,[16] in joining freely in the Ohio boundary controversy,[17] and in attempting to enter into a compact with Congress regarding the disposition of certain public lands within the Michigan Territory [18]

[10] *Democratic Free Press*, May 28, 1835

[11] *The Michigan Whig*, May 28, 1835 This opinion was shared by many others Russell Briggs, a delegate from Washtenaw, said that the idea of legislative control "*was to his mind truly preposterous*." See *The Monroe Sentinel*, May 23 1835 Ross Wilkins, territorial judge and delegate from Lenawee, thought that, even though the convention had been convoked to form a constitution, it might in view of a crisis attend to other affairs See *Journal and Courier*, May 20, 1835

[12] *Journal of the Proceedings of the Convention to Form a Constitution for the State of Michigan* (Detroit, 1835), pp 169–170, 190, 195–196, 198, 222

[13] *Ibid*, pp 71 72

[14] *Ibid*, pp 205–206

[15] *Ibid*, p 210

[16] *Ibid*, p 32

[17] *Ibid*, p 11 *et passim*.

[18] *Ibid*, p 219

Likewise, it exercised its discretionary powers in determining whether or not the constitution should be submitted to the people for approval [19]

Pursuant to the Act of January 26, the delegates elected in the April election met at the Capitol in Detroit on the morning of the second Monday in May, 1835,[20] and proceeded to form a convention to frame a constitution for the proposed state Though the delegates were men of integrity and possessed of sound political convictions, they were, for the most part, wanting in political experience, in an understanding of parliamentary procedure, and in a knowledge of the fundamentals of constitutional law Among their numbers there were, however, several who had had experience as members of the territorial legislature or courts, and, in a few exceptional cases, the delegates' political activities had not been confined to affairs of the Territory These few were adequately qualified to lend intelligent leadership to the convention and properly direct its activities [21]

The convention was a truly typical cross-section of the life in the Territory at the time The democratic victory in April had been a sufficient guarantee that the interests and points of view represented were to be those of the masses of the people rather than those of the more fortunate few In the selection of delegates by far greater emphasis had been placed upon their ability to understand the needs and the desires of the people than upon their ability to interpret these needs and desires in legal and constitutional forms Reflecting the economic status of the Territory, almost all the delegates were men of small means — a few were wealthy in their own

[19] *Ibid* p 27

[20] Seventy three delegates presented their credentials in time to participate in the opening session The remainder appeared in the course of the next two days The credentials of all but two of the eighty nine delegates had been approved by the committee on elections by Wednesday, May 13 See *Journal of the Convention* pp 9 10, 20–22

[21] William Woodbridge had served in both houses of the Ohio legislature before removing to Michigan Among the most important offices he filled in the Territory were secretary and acting governor, delegate to Congress and judge of the territorial court At the time of the convention Lucius Lyon was territorial delegate to Congress Ross Wilkins was prosecuting attorney in Pittsburgh Pennsylvania, when appointed to the territorial court by President Jackson John McDonell had served several terms as president of the Legislative Council John Biddle and John Norvell had been actively interested in public affairs in one capacity or another, throughout their lives The former served one term as territorial delegate to Congress.

right or were agents of wealth — and over one half of them were actively identified with agricultural pursuits [22]

Approximately fifty per cent of the delegates were actively engaged in farming, a few divided their time between their farms and other occupations About twenty were occupied in business pursuits as merchants, mill-operators, lumbermen, and traders, but almost all were selected from among the less prosperous classes [23] There were among them at least ten lawyers actively engaged in the practice of their profession, and several others who had had some legal training Among the remainder were two surveyors, three doctors, an editor, an architect, and a school-teacher [24]

Likewise, the social position and the educational advantages enjoyed by the delegates were fairly representative of those of the people generally Many had received excellent training in the elementary schools of the older states, some had attended academies and colleges, but for the most part their education was of a more practical nature, acquired outside books and classrooms [25]

[22] A majority of the delegates were of New York and New England origin The published biographies of seventy-two of the delegates disclose the following distribution according to birth

New York		27	Other states		7
New England		15	Michigan	5	
Connecticut	6		Ohio	1	
New Hampshire	3		Kentucky	1	
Vermont	3		Foreign countries		9
Maine	2		Ireland	3	
Rhode Island	1		Canada	2	
Middle Atlantic		14	Scotland	2	
Pennsylvania	7		England	1	
New Jersey	5		France	1	
Virginia	2				

Several born in other states spent considerable time in New York before immigrating to Michigan See *Michigan Biographies* (Lansing, 1924)

[23] Many of these small businesses laid the basis for large commercial organizations.

[24] "We [Wells and Adam] were the youngest members of the convention, elected, possibly, *for the mere purpose of contrast*, for in the assemblage were men with whitened locks and large experience in life, men of almost every vocation were there, the largest proportion of farming class, mechanics, millers, and editors, also clergymen, some of the medical profession ", and the lawyers. "Such was the composition of the convention, the largest proportion of them eminently practical men " See H G Wells, "A Sketch of the Members of the Constitutional Conventions of 1835 and 1850," *Michigan Pioneer and Historical Collections* (hereafter cited as *M P H C*), III (1879–80) 37

[25] Very few of the delegates were college graduates, John Biddle had gradu-

As the convention denoted an economic and political turning point in the history of Michigan, it marked a similar period in the lives of many of the delegates Most of the delegates were men approaching the prime of life,[26] about to reap the rewards for their early sacrifices and endeavors Before the assembling of the convention a vast majority of the delegates were unknown beyond their immediate communities, since their political experiences had been limited to the inauspicious realm of local politics But election to the convention presented to those who were politically ambitious an opportunity for rapid advancement Approximately fifty per cent served thereafter at least one term in the Michigan legislature, and six were later elected to the Congress of the United States — three to each House [27] Three served as governors of the state and one as lieutenant governor,[28] and two made enviable records as Supreme Court justices [29] The high and responsible positions so creditably filled in later years by these men attest the lofty character of the first constitutional convention of Michigan [30]

Edward D Ellis, a delegate from Monroe and editor of *The Michigan Sentinel*, thus characterized the assemblage for the benefit of his readers "The convention is composed of about 90 members

ated from Princeton, Edward Mundy from Rutgers College, Hezekiah Wells, from Kenyon College, Isaac Crary, from Trinity College, Ross Wilkins, from Dickinson College, Pennsylvania, John Adam held a college degree conferred in Scotland, Ebenezer Raynale was a graduate of a medical college

[26] The average age was forty four years The oldest member was Louis Beaufait, seventy-five years of age, the youngest, Hezekiah Wells, twenty-three

[27] Lyon Norvell, and Woodbridge were elected to the Senate, Crary, Lyon, and McClelland, to the House Biddle, as a Whig candidate, barely missed election to the Senate

[28] McClellan, Barry, and Woodbridge Mundy was the first lieutenant governor of Michigan

[29] Manning and Mundy Among others who acquired political fame were Adam, Wells, and Wilkins Many of the delegates became completely absorbed in their businesses and professions and played a part in the development of the state comparable to that of those who sought political advancement Several of the delegates sat also in the constitutional convention of 1850, namely Ammon Brown, Isaac E. Crary, Robert McClelland, Seneca Newberry, Ebenezer Raynale, Alex R Tiffany, and H G Wells. The latter was also a member of the constitutional commission of 1873

[30] "*It was one of the ablest bodies of men ever assembled in Michigan* It embraced in its membership future congressmen United States senators, several governors, a justice of the Supreme Court, a United States judge, and a cabinet officer" (McClelland served as Secretary of Interior under President Pierce) See H M Utley and B M Cutcheon, *Michigan as a Province, Territory and State, the Twenty-Sixth Member of the Federal Union* (New York, 1906), II 320

— as intelligent a body, perhaps, as has ever before assembled on a similar occasion The people in their selection, doubtless, had a singular eye to their practical good sense and honesty rather than to their brilliancy There are nevertheless a sufficient number of gentlemen of *showy* talent, to render our deliberations both amusing and interesting and, indeed, there is scarcely one of the whole body who is not capable of expressing himself creditably and publicly "[31]

Intent upon harmonizing intraparty differences off the floor of the convention and capturing the delegation with a smooth-running organization, the Democratic leaders called a party caucus for Monday morning prior to the first session[32] The Democratic nomination for the presidency was tendered to John Biddle, of Wayne, only after Lucius Lyon and John McDonell had declined to serve in that capacity Owing to the overwhelming Democratic majority this nomination was tantamount to election, the Whigs offered no candidate and Biddle was elected on the second ballot[33] The organization was completed in the following days with the adoption of rules and the naming of standing and select committees As might have been anticipated, the organization and procedure were patterned after those of the legislative council and were reshaped as necessity demanded[34]

With such a model the completion of the preliminary organization was a relatively simple matter But when the delegates directed their attention to the more difficult task of drafting a constitution, being without legislative precedents, the dearth of political experi-

[31] *The Michigan Sentinel*, May 30 1835

[32] *The Statesman* May 23 1835

[33] On the first ballot Biddle received twenty-six votes, Mundy twenty-two, Lyon ten, Wilkins, eight, and McDonell, two On the second Biddle received thirty-six votes against twenty two for Mundy and was declared elected See *The Ann Arbor Argus*, May 23 1835 The other Democratic nominees were also elected, namely Charles W Whipple and Marshall J Bacon, secretaries, Olmstead Hough, sergeant-at-arms, and Thomas Lee, doorkeeper The president was the only official chosen from among the delegates

[34] The first standing committees named were rules, legislative, executive, judiciary, elective franchise, miscellaneous affairs and elections Other committees were named as necessity or whim dictated, among them those to draft a constitution, expenditures, to arrange the constitution, University lands, education, internal improvements, militia, incorporations, bill of rights, boundaries, printing, appointing power and tenure of office, change of the territorial government, ways and means, apportionment, capital punishment, amendment, submission, name of state and revision Among the select committees were those on the Ohio boundary controversy, order of business, and expediency of daily prayer

ence and adequate leadership became evident Many of the delegates, professing no knowledge of constitutional law or procedure, had, nevertheless, numerous provisions which they hoped to incorporate in the constitution [35] These were presented in the form of resolutions and disposed of, in the absence of a suitable procedure, by reference to one of the standing committees A majority of these resolutions pertained to the body of individual liberties set forth in state constitutions, or were proposed limitations upon the agencies of government, designed to secure individual freedom Unfortunately, these resolutions contributed nothing fundamental, but added to the original confusion and incited a considerable amount of debate on trivial matters during the opening days of the session All in all ten days elapsed before the convention became seriously engaged in the business of drafting a constitution [36]

Among the delegates there were, however, a few who had foreseen the evident difficulties and sought to avert further confusion and disorders To this end Edward D Ellis, of Monroe, introduced a resolution on May 13, calling for the appointment of a committee of nineteen members, "whose duty it shall be to prepare and report to the Convention, for their consideration, a draft of a constitution for the contemplated state of Michigan" [37]

This committee met as a whole on the fourteenth and fifteenth to undertake its commission, but it was at once evident that it could not function It was large and unwieldy and represented too many shades of opinion With its usefulness thus threatened, Ellis overcame the difficulty by selecting five of the members to prepare the draft in secret "They met [at John Brunson's] and in secrecy worked night and day, when not attending the sessions of

[35] "Until then the convention had made no progress, for there were a number of the delegates who had a pet theory on this or that subject, that each wished to see embodied in the constitution, and was working to bring about It was easily seen that but little if any real progress could be made in the direction they had gone." — George H White, "Townsend E. Gidley," *M P H C*, XIV (1889) 407

[36] "Thus up to May 18th, inclusive, we see the convention have merely got organised, and have, as yet, approached no question of constitutional law" — *The Statesman*, May 23, 1835

[37] *Journal of the Convention*, p 17 The resolution was immediately adopted and the following delegates were appointed by the president Ellis, Ferry Van Every, Beaufait, Herrington, Irwin, Chapman, Newberry, Miller, O White, Noble, Brewer, Ellenwood, Curtis, H Porter, Gidley, Crary, Odell, and Shellhouse

the committee, and completed such a draft, and presented it to the committee on the 18th, somewhat to the surprise of all except the five "[38]

This committee made its first report to the convention on the nineteenth In this report it presented for consideration a partial draft of a constitution, which included a bill of rights, a provision on the distribution of power, and an article on each of the three departments of government[39] With the submission of the report the convention for the first time turned its attention to its primary purpose, the drafting of a constitution

Not only did the draft present concrete proposals for consideration, but it suggested a mode of procedure which greatly facilitated its labors The proposals were divided according to subject-matter, and each general topic was referred to a standing committee for further study After a more or less careful investigation these committees reported the articles, together with amendments and recommendations, to the convention, where they were considered in committee of the whole In almost all cases it was at this stage of the procedure that the articles were whipped into final form, and adequate majorities were created to insure adoption Further debate was, however, unrestricted, and in a few exceptional cases was prolonged before final agreements were obtained[40] Roll-call votes were avoided whenever possible, being resorted to only on questions of close division or upon demand After their adoption the articles were referred to an arranging committee and in turn inspected by a committee on revision[41] The completed document was ordered engrossed on parchment and was presented to the delegates for their signatures[42]

In spite of this more regular mode of procedure the convention was unable to complete its labors within the time the delegates had

[38] White *op cit*, p 407

[39] *Journal of the Convention*, pp 37-38 The remaining articles of this original draft were presented to the convention on the following day *Ibid* pp 41-42

[40] A resolution limiting debate was introduced, but promptly rejected by the convention *Ibid*, p 119

[41] This committee reported the article on the elective franchise back to the convention for revision The recommendation of the committee was adopted by the convention as Article II of the constitution *Ibid*, p 207

[42] Twelve delegates were absent when the final vote was taken Of those present seventy-five voted in favor of adoption, Woodbridge and Gidley voted against adoption but signed the instrument *Ibid*, p 223

anticipated being away from their homes and businesses Again, many delegates evinced little interest in the constitution beyond those provisions dealing with the elective franchise, the bill of rights, and special privileges Consequently, some of the provisions were hastily drawn and were given but little consideration In a few instances important provisions were adopted upon the recommendations of the standing committees [43]

After thirty-eight days the convention adjourned *sine die* on the twenty-fourth day of June This was not an especially long session, yet an analysis of the proceedings demonstrates that the constitution could have been framed in a much shorter time In addition to the ten days which were practically wasted at the opening of the session a disproportionate amount of time was consumed in the consideration of extraneous and immaterial matters [44] and of affairs more properly within the sphere of legislative authority [45] Furthermore, the allocation of time is significant of the temper of the period and the political interests of the delegates Those articles of the constitution providing for the three departments of government, the amending process, and education were disposed of in approximately seven days In direct contrast to this dispatch more than five days was devoted to the article dealing with the elective franchise, and the bill of rights claimed the attention of the convention for more than three days And again, aware of the evils which centered about the granting of special privileges in the older states, the convention spent many hours in the discussion of methods for the control of corporate grants

The conditions under which the convention of 1835 was assembled and the character of the delegates elected predetermined the nature of Michigan's first constitution To these practical men the adoption of a constitution and the creation of a state government involved no serious problems in the theory of government Political developments in the Territory during the Cass administration had

[43] See Art X, Education *ibid*, pp 120–125, and Art XII Sec 3, Internal Improvements, *ibid*, pp 187–188

[44] The Ohio boundary controversy, name of the state, location of the capital, and various phases of the question of religion

[45] Capital punishment mechanics' lien, imprisonment for debt and salaries In answer to the criticism that the convention was disposed to legislate, Edward D Ellis said in *The Michigan Sentinel*, June 20, 1835 ' such may be the case taking our daily deliberations as a guide, but in the long run such matters are usually cast aside "

reproduced in Michigan a system of government not unlike that in the older states This system was basically sound and readily adequate to the expanding needs of the Territory, but was unsatisfactory in that the people were compelled to look to Washington as the source of all authority There were, then, in the adoption of a constitution no revolutionary steps to be taken, it was necessary only to bring the existing system into conformity with American constitutional practices Only such fundamental changes were desired as would place the ultimate control of government in the hands of the people and render to Michigan the right to participate in the management of national affairs Since this could be effected without disrupting the established order, there was no temptation to introduce "untried novelties" in the field of state government This combination of circumstances under which the constitution of 1835 was adopted demanded nothing from the convention beyond the application of familiar precedents, nor were the delegates disposed to exceed these demands Consequently, that document exhibits no unusual political features or startling innovations

Inheriting much of the New England philosophy of government and tempered by frontier experiences in western New York, the delegates were strongly inclined toward the theories of popular sovereignty, political equality, and individual liberties These theories found practical application in the Michigan constitution The document was prefaced with a liberal bill of rights, which reserved out of the sphere of government a large body of individual liberties and preserved to the people the usual judicial and political guarantees These were stated concisely as legal precepts and "all acts of the legislature contrary" thereto were declared void [48] Political equality and other democratic principles were incorporated in the form of a liberal suffrage clause, the liberal qualifications for office holding, the establishment of public schools, and the authorization of internal improvements at public expense Frequent elections were assured and constitutional changes made amenable to public control With these as its outstanding features the constitution of 1835 was thoroughly conservative and yet, at the same time, was truly democratic

Beyond these features, which must not be considered radical

[48] *Michigan Constitution of 1835*, Art. I, Sec 21 Reprint (Bulletin, No. 2), Michigan State Library Legislative Reference Department, 1907

departures from the established type, the Michigan constitution was decidedly reactionary This is evident in at least three features of the document The delegates evinced no distrust of legislative assemblies such as was current in many of the older states, and, consequently, the constitution is relatively free from substantive and procedural restrictions designed to limit the activities of the legislature It followed rather the New England practice of resort to political sanctions [47]

In the second place, this constitution did not attempt to invade the general field of legislation, but "was carefully restricted to prescribing the fundamentals of government and the general framework of official organization In this respect it may well be regarded as a model" [48] In the details of governmental organization and in prescribing official duties it vested in the legislature broad discretionary powers, thus enabling the legislature to adapt the governmental organization to the rapidly expanding needs of the state This feature was an evident source of pride to the delegates In this connection Edward D Ellis, a delegate from Monroe, wrote "The constitution is brief and contains not a solitary superfluous paragraph or even phrase It is pronounced by all who have examined it, to be one of the most plain, finished and Republican instruments to be found in the Union" [49]

Prior to 1835 repercussions of Jacksonian democracy had set in motion a movement for the popular election of all state and local officers Though this movement had progressed far enough to attract attention in Michigan, nevertheless, the framers of the first constitution deliberately chose the more conservative tendency of the northeast and provided for the appointment of all state administrative and judicial officers The election of local officers was extended somewhat to include justices of the peace and "judges of all county courts, associate judges of circuit courts, and judges of probate" [50]

[47] In contrasting the constitution of 1835 with the one of 1850 Jas V Campbell (*op cit*, p 464) said "This constitution *is* very simple, and very much better adapted to the changing necessities of a growing State than the present one [1850]. While it restrained such abuses as it was thought would be dangerous it left to the Legislature broad discretion"

[48] Cooley, *op cit* p 225.

[49] *The Michigan Sentinel*, June 27, 1835

[50] *Michigan Constitution*, 1835, Art. VI, Secs 5–6

Considered as a whole, the Michigan constitution of 1835 was a brief and concise document, admirably adapted to the needs of a people undergoing rapid political changes An analysis of the provisions of the instrument marks it as a thoroughly practical document Exclusive of the schedule and the trouble-making preamble, it consists of thirteen short and well-arranged articles, expressing in clear and unmistakable terms the political relationships under which the people desired to begin their statehood career

The preamble, quite unlike those in most state constitutions, may well be considered a declaration of political independence It served warning to Congress that the Territory had come of age and was determined to exercise the inherent rights of statehood Reciting the conditions of admission set forth in the Ordinance of 1787 and subsequent acts of Congress, the preamble declared, in the name of the people of the Territory, "that the time has arrived when our present political condition ought to cease and the right of self-government be asserted"

The declaration of rights, borrowed largely from the constitution of Connecticut (1818), declared that "all political power is inherent in the people," and that "government is instituted for the protection, security, and benefit of the people" and should be forever subject to their control [51] With this brief reference to eighteenth-century political philosophy, the article proceeded to an enumeration of that body of personal liberties believed essential to any free government, and concluded with a positive assertion of the doctrine of constitutional supremacy [52] The doctrine of separation of powers, slightly different from its New England prototype, was proclaimed in a distinct article,[53] as was a declaration against the introduction of slavery [54]

The question of the elective franchise excited more interest and was debated with greater zeal than any other provision The contest arising out of the provisions of the "Doty Bill" [55] was carried from the legislative council, through the campaign preceding the election of delegates, and on to the floor of the convention The

[51] *Michigan Constitution*, Art I, Secs. 1-2

[52] "All acts of the legislature contrary to this or any other article of this constitution, shall be void" — Art I, Sec 21

[53] Art III

[54] Art. XII

[55] The Statehood Act, enfranchising aliens, sponsored by Judge Doty

liberal Democrats, under the leadership of John Norvell, were determined to ingraft upon the constitution the same liberal suffrage qualifications they had temporarily imposed upon the Territory These proposals were, however, too radical to appeal to the more conservative wing of the party, and a determined stand by the conservative members of the convention succeeded in frustrating the plan The qualifications imposed were, however, extremely liberal and were bitterly opposed by the Whigs [56]

The constitution granted the right to vote in all elections to "every white male citizen above the age of twenty-one years, having resided in the State six months next preceding any election , and every white male inhabitant of the age aforesaid, who shall be a resident of this State at the time of the signing of this Constitution " [57] The article was a distinct disappointment to the radical Democrats, yet was among the most liberal to be found in any state constitution Liberal to the extreme in prescribing suffrage qualifications, the convention was more conservative in determining its application County and township officers were to be chosen by popular elections, but, among the state officials, only the members of the legislature, the governor, and lieutenant governor were elected in a similar manner

The legislative powers of the state, with few constitutional restrictions, were vested in a bicameral legislature — a senate and a house of representatives The legislature was required to meet annually, on the first Monday in January, and at no other time "unless otherwise directed by law" or called into special session by the governor The constitution carried a few procedural restrictions such as were intended to prevent legislative abuses of power, and, as a further check, clothed the executive with the Massachusetts type of veto [58]

"The supreme executive power" was vested in a governor elected by the qualified voters for a term of two years [59] Few qualifications beyond those of an ordinary elector were prescribed, the chief executive was required to have been a citizen of the United States for five years, and two years a resident of the state The

[56] See Whig protest, *Journal of the Convention*, pp 106–110

[57] Art II Sec 1

[58] Art IV

[59] A lieutenant governor was elected for a similar term His principal duty was to preside over the Senate

constitution enumerated the ordinary list of executive powers [60] Minor constitutional executive offices were created, but the duty of filling them was quite wisely divided between the governor and the legislature [61]

Evidently satisfied with the system of courts and local organization as developed under the territorial régime, the constitution avoided any abrupt changes in the organization of either Quite wisely the legislature was left relatively free to shape the organization, jurisdiction, and procedure of the judiciary to the changing needs of the state The constitution elevated the justice of the peace to the dignity of a constitutional position, provided for a probate court in each organized county, and vested the general judicial power in "one Supreme Court and in such other courts as the Legislature may from time to time establish" [62]

The present county-township system of local government was constitutionally riveted upon the state by an implied recognition of the territorial local organization and the constitutional creation of certain county officials It was tacitly understood that the legislature should continue to control the local units through general and special acts [63]

In order to enforce official responsibility the legislature was granted broad powers of removal, which extended to all state and local offices According to legislative custom, either house was permitted to expel a member, but "no member shall be expelled a second time for the same cause, nor for any cause known to his constituents antecedent to his election" [64] All civil offices were subject to impeachment, and the legislature was to provide by law for the removal of local officials The constitution provided further that "for any reasonable cause, which shall not be sufficient ground for impeachment," judicial officers should be subject to removal by the governor, upon legislative address [65]

Beyond creating the ordinary agencies of government and prescribing duties, the convention incorporated in the constitution two progressive and interesting provisions Both were indicative

[60] Art. V

[61] The constitution provided for a secretary of state, a state treasurer, an auditor general, an attorney-general, and a prosecuting attorney for each county Art. VII, Secs 1–3.

[62] Art. VI

[63] See limitation of size of counties, Art. XII, Sec 7

[64] Art IV, Sec 11

[65] Art. VIII

of the hopes and ambitions of the people, but differed widely in ultimate consequences The constitution of 1835 carried a more nearly complete and enlightened article on public education than had appeared in any previous state constitution [66] It carried also a provision intended to encourage internal improvements at public expense [67] The former provision has remained as the basis of public education in the state for nearly a century, the latter, in the space of a few years, rushed the young state to the brink of bankruptcy

In keeping with the spirit of the times and the democratic proclivities of the people, all constitutional alterations were made amenable to public control Recognizing the evident distinction between amendment and complete revision, the constitution provided for subsequent changes by either process Minor alterations in the form of amendments might be proposed by legislative action, but the convention system was chosen for the drafting of fundamental and sweeping changes In either case, however, the proposed alteration could be definitely effected only by popular approval [68]

The question of whether or not the constitution should be submitted to the people for approval had been one of the chief points of contention in the statehood law, and was raised before the convention [69] at an early date In accordance with the recommendation of the committee appointed to study the question, the convention voted to submit the constitution "to the electors qualified by this constitution to vote at all elections," for approval The election for this purpose was set for the first Monday and Tuesday in the following October [70]

The adoption of the constitution was generally anticipated The modified suffrage provision dictated by the conservative Democrats destroyed the effectiveness of Whig opposition, consequently, the constitution was ratified by an overwhelming majority Under its first, and in many respects its best, constitution Michigan began, on the first Monday in November of 1835, its independent political career, as a "state outside the Union"

University of Michigan

[66] Art. X. [67] Art. XII, Sec 3 [68] Art XIII

[69] *Journal of the Convention*, p 27 [70] *Schedule*, Sec 9

THE COURT OF THE COMMONWEAL

WALTER C RICHARDSON

AMONG the numerous letters, papers, and memoranda of Thomas Cromwell preserved in the Public Record Office is a draft bill of Parliament which has somehow escaped the notice of historians [1] This singular document of twenty-seven pages is now classified among the State Papers of the reign for the year 1534, although it is undated and has no heading It is literally the draft of the constitution of a new Court of the Commonweal, which was to be erected by act of Parliament [2]

Unfortunately, we have no further enlightenment regarding the history of this bill, though the draft itself shows a most careful consideration for both the organization and the jurisdiction of the court, and that by a master hand [3] If Wolsey was the diplomat of Henry's reign, Cromwell was the adroit manager of parliaments, and we wonder why the bill never became a law It was in direct keeping with the general scheme of the centralization of authority, the definite organization and departmentalization of institutions, and the close supervision of justice of the "new monarchy" [4] Crom-

[1] The bill is barely mentioned by H A. L Fisher in *A History of England from the Accession of Henry VII to the Death of Henry VIII* (New York 1928), p 346

[2] (P R O) S P 1/88 fols. 26–39 Gairdner also included it in the calendar among the other Cromwellian papers for the year It directly follows two other draft bills and a petition of the Commons in Parliament against the abuses in the administration of the law The abstract of the draft in *Letters and Papers of the Reign of Henry VIII* , VII, No 1611 (4), is very brief, affording little idea of the exact nature of the proposed court

[3] Just what part Cromwell did play in devising plans for augmenting revenues for the king and for the more efficient administration of that revenue and of justice is not known But it is not unlikely that he framed the statute concerning first fruits (26 Henry VIII, c 3), or that much of the legislation of the period was the fruit of his abstruse mind (B M) MSS Cotton , Cleop E, IV, fol 179 See also *Letters and Papers of the Reign of Henry VIII* , VII, Nos. 62, 107, 108, 583, 923, *et passim*

[4] The administrative system of the Tudors, the effects of which can still be traced in certain English institutions, was begun by Henry VII and a few of his most capable ministers But the various offices were formative in character and

well possessed all the qualifications for the execution of such a program, and this particular plan illustrates the extreme limits to which he was willing to go in accomplishing his purpose Whatever may have been his original intentions, the scheme was later abandoned for the more important business that was then confronting him [5] Most probably the measure never reached Parliament at all, since we find no further trace of it either in the *Letters and Papers of the Reign of Henry VIII* or in the *Journal of the House of Lords* [6] Even so, such an expedient as this would doubtless have little favor with a people already too heavily burdened with restrictions of purse and liberty Our interest in the court lies, however, not so much in the possible effect it might have had as in its relation to existing practices and the light it throws upon certain tendencies of the time

The 'thirties of Henry VIII's reign were particularly fruitful in revolutionary legislation The Reformation had been definitely established, a system of espionage had been set up to guarantee the abrogation of papal authority, the monasteries had been dissolved and their property forfeited to the Crown, the secularisation of abbey lands had been completed, special treasons had been created, and new financial institutions erected to take care of the spoils of the Dissolution and administer the augmented revenues of the Crown It was a period of high-handed curtailment of free speech and personal liberty, a time in which the contemplated Court of the Commonweal could have quickly assumed a strong position The act called for the appointment of six discreet men, to be known as justices or conservators of the commonweal, who, sitting together in Whitehall at Westminster, were to constitute a court for the discussion of all matters pertaining to the commonweal, with power to summon before them all persons who had violated any act of

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transitional and personally directed by the king until Henry VIII, not having time or caring to be burdened with so much personal responsibility, departmentalised them by letters patent and acts of Parliament

[5] To all practical purposes the whole secular government of the kingdom was in the hands of Cromwell, who had succeeded Gardiner as the king's chief secretary (*Letters and Papers of the Reign of Henry VIII*, VII, No 483) Henry had already disclosed his intention of uniting the property of the Church to the Crown (*ibid*, VI, No 235, Chapuys to Charles V, 15 March, 1533) The visitation and suppression proceedings were soon to occupy most of Cromwell's attention

[6] *Journal of the House of Lords*, Vol. I This contains both the Rolls of Parliament from 1513 to 1533 and the Lords' Journals from 1509 to 1513 and from 1533 to 1547

Parliament since the beginning of the reign of Henry VII The conservators were, moreover, authorized to appoint deputies or sergeants of the commonweal in every county to search out all offenders and report them to the court Though there are no particular precedents for such a court, it is certainly no radical departure from the general policy and practices of the Tudor kings The powers given by Henry VII to his ministers, Empson and Dudley, who, in the well-known words of Bacon, "turned law and justice into worm-wood and rapine,"[7] were not unlike those entrusted to the conservators and sergeants[8] Although the spirit of the act was for the better administration of justice, it might easily have led to unwarranted extortions Henry VII also set up another expedient for revenue administration which embodied some of the elements of Cromwell's plan The extraordinary office of surveyor of the king's prerogative, created in 1508 for the purpose of augmenting the revenues of Crown lands, especially through the closer supervision of the person and property of widows, lunatics, wards, and outlawries, was similar in organization to the Court of the Commonweal The surveyor had the authority to appoint county surveyors under him who had, among other duties, that of inquiring into "concealments" of landowners and land officials and of seizing for the king the property of all persons convicted, attainted, outlawed, or waived for felony, murder, or like offense The surveyors had complete charge of the land and property of such persons, could hold juries or other forms of inquiry, collect revenues, and assess and levy fines, accounting to no one save the two auditors especially appointed

[7] Bacon, Francis, *History of the Reign of Henry VII* (*Works*, XI, ed J Spedding, New York, 1864), p 325

[8] Stow gives a rather clear picture of the system employed by Empson and Dudley, who, like the conservators, had men working for them Of the year 1507 Stow writes "This yeere or rather somewhat sooner, sprang much sorrow through the land, by meane of gracelesse persons, which named themselves the kings Promotors, many forgotten statutes, made hundreds of yeeres passed, were now quickened, and sharpely called vpon, to the great vnquietnesse of many the kings subiects, as well the rich as the other that had competent substance, yet now, since Empson and Dudley were set in authority, many mo in number were called before them, for many surmised causes, of the which none escaped without paying of fines. And if it were such a matter, as some would abide the triall of the law, then had they false Jurors so fired vnto them, that they were well assured, that they would passe against their wils, for all was done in the King's name, and yet the most profit came to other mens coffers ' John Stow, *Annales* (London, 1631), p 485.

to hear their accounts [9] Heretofore work of this nature had been performed by special commissioners, appointed from time to time as the need arose, and the surveyorship of the prerogative was an attempt to departmentalize the work of several commissions by uniting them in a central office with jurisdiction over the entire realm At the same time it would serve as a profitable and convenient tool for the king That is exactly what the Court of the Commonweal provided for in the administration of justice — the more speedy execution of the law to the increase of the king's profit

The Court of the Commonweal, if instituted, would have been but one more of the many which did develop under the firm and vigorous hand of the second of the Tudors [10] Aside from the fact that such new creations were absolutely necessary,[11] as was the Court of the General Surveyors and that of the Augmentations, they were also a part of the general policy of augmenting the royal revenues Whether or not we can justify these acts and the institutions which they set up is another question They were not the people's courts, they were the king's courts, and as such they served his purpose The principle that the king reigns but does not rule had not yet developed, whatever was the nation's was the king's, to be employed to his own personal profit and advantage if he cared to use it so [12] For example, the royal navy was still styled "the

[9] Pat Rolls, 23 Henry VII, p 3 mem 24 (3) Edward Belknap held this singular office for five years, being released in 1513 (Pat Rolls 5 Henry VIII, p 1, mem 12) to assume the duties of general surveyor of Crown lands (Pat Rolls, 6 Henry VIII, p 2, mem 19) Fortunately, some of Belknap's accounts are preserved, of which two are beautiful specimens of early sixteenth-century accounts (Accounts Exchequer, Q R, 517/14, and 517/15)

[10] The Court of Augmentations, 27 Henry VIII, c. 27, the Court of First Fruits and Tenths, 32 Henry VIII, c 45, the Court of Wards, 32 Henry VIII c 46, the Court of Wards and Liveries, 33 Henry VIII, c 22, and the Court of General Surveyors 33 Henry VIII, c 39 This last court had, however, existed in continuity from the time of the late king Henry VII See Acts 3 Henry VIII, c 23, 4 Henry VIII, c 18, 6 Henry VIII, c 24, and others relating to the general surveyors (*Statutes of the Realm* III)

[11] These institutions were more financial than judicial in character, being designed as administrative organs to take care of the great increase in Crown lands and revenues. The old exchequer process was highly inadequate, having broken down during the period of the long War of the Roses The most striking evidence of exchequer decay is to be found in a financial document of the reign of Richard III (B M), MSS Harl 433, fol 271 Part of this pocket-book of Richard's chancellor, Bishop Russell, is included in Gairdner, *Letters and Papers of the Reign of Richard III and Henry VII* (2 vols., London, 1861–63) I 81–85

[12] This fact must be kept uppermost in mind if we care to understand the

king's ships"[13] The chamber system of finance and administration which had been revived by Henry VII was giving way under Henry VIII to departments with fixed forms and limitations, and with it passed the last vestige of medieval household practices[14] We shall have overcome our first great difficulty in studying the history of the late fifteenth and early sixteenth centuries if we refrain from the temptation to explain these early institutions in the light of modern knowledge and by the use of present-day terms[15] When we remember that the English Crown and Government, even in the so-called modern period, were in many ways essentially medieval in character, we have gone a long way in interpreting the period aright This form draft of the office of justices of the commonweal offers an excellent example of an attempt to mold medieval characteristics into a form compatible with sixteenth-century practices Through it local control could be further centralized and forced financial extractions more easily secured

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king's absolute power Every act of his, either private or public, was a royal act As Stubbs has so aptly pointed out, Henry VIII was never an individual, he was always a king, looking on kingship as an end in itself, on kingly volition as the only and ample reason for anything whatever Wm Stubbs, *The Study of Mediaeval and Modern History* (Oxford 1900), p 281

[13] See the discussion by Captain C S Goldingham, "The Navy under Henry VII," *The English Historical Review*, 33 (1918) 472–488 We find Henry VII employing his ships for private ventures The account books of the King's Chamber are filled with such items This continued until Henry VIII gave the navy a definite organization in keeping with his policy of administrative departmentalization See M Oppenheim, *A History of the Administration of the Royal Navy and of Merchant Shipping in Relation to the Navy* (London 1896) The work contains a valuable collection of materials, though it must be used with extreme care

[14] See A P Newton's article, "The King's Chamber under the Early Tudors," *The English Historical Review*, 32 (1917) 348–372, and also the excellent treatment of the earlier history of the *Camera Regis* in T F Tout *Chapters in the Administrative History of Mediaeval England* (5 vols., Manchester At the University Press, 1920–30), especially Vol 1

[15] We continue carelessly to apply to early sixteenth-century institutions modern terms, which carry with them modern connotations, without the slightest consideration of their appropriateness. The Privy Council, the Star Chamber and the Court of Requests all are in a process of great change and development under Henry VII and Henry VIII Who can tell us just what was the royal prerogative in 1500, or even in 1530? What interpretation and legal significance did the term "court" have in 1532, the period we are now considering? It indubitably carried a medieval and not a modern connotation Certainly a revenue court like that of the great Augmentations was vastly different from that of the Star Chamber, the "high court of parliament" or from Wolsey's special Court of Requests. The term "court" admitted of many meanings in its earlier usage. Even in the institutional sense we must interpret it very carefully

To appreciate the importance of this document one must be sympathetically interested in that yet unwritten chapter of early Tudor administrative history of which it forms a part It seems somewhat strange that, with all the work done on the Tudor period, this phase has not been attempted [16] Tout's brilliantly written work on medieval administrative history has well paved the way for such a study [17] Edward IV had begun the policy of remedying English domestic troubles by strengthening the Crown, a practice which was completely consummated by Henry VII and his son As Tout suggests, Tudor practice involved no radical departures "Its devices for improving central control and establishing public order were all borrowed from the armoury of the Plantagenets " [18] The intended court was but another royal expedient to enforce central authority [19] Cromwell not only fulfilled his vow to make his master the wealthiest prince in Christendom, but he also sought to maintain peace and order in the kingdom through the better administration of justice Although he may not have been the best guardian of the commonwealth,[20] Cromwell and the king saw to it that, whenever opposition to royal measures or local disturbances arose, they were nipped in the bud by the king's officials [21] And yet, says the preamble to this bill, of the many

[16] The one attempt made by Dietz in 1921, may be dismissed as highly inadequate, although he has compiled a good deal of information that is very useful See F C Dietz, *English Government Finance, 1485–1558* (Vol. IX, No 3, of University of Illinois Studies in the Social Sciences, 1920) The writer hopes to throw some light on the problem when he completes a study on the administration of land revenues under Henry VII and Henry VIII, which will involve for the later years of Henry VIII s reign an intimate and detailed examination of the Augmentations and other related financial courts of that century

[17] Tout, *op cit*, I 28–29

[18] *Ibid*, IV 67

[19] Beard was absolutely correct in saying that "no continental state possessed such a combination of local independence and central control" as did England during the Tudor régime See Charles A Beard, *Justice of the Peace in England* (New York, 1904), p 71 (published in Columbia University Studies in History, Economics and Public Law, XX, No 1)

[20] Richard Morrison in a letter to Cromwell in 1534 advises him, as present guardian of the Commonwealth, how best to pilot the ship of state One admonition was heeded: "The best defense of a kingdom is the consent of the inhabitants." Henry, through various exigencies, whether coercive or not, caused all his actions to evolve through the desire and by the apparent consent of the people. This explains why Parliament became such a tool, obedient to the will of the powerful monarch. *Letters and Papers of the Reign of Henry VIII*, VII, No 1318

[21] See articles touching a riot at Hoddesdon in that year *Ibid.*, No 1120 On the whole, the king's wishes were carried out by the people "like true subjects." Any murmur of discontent was promptly suppressed Even compara-

laws enacted since 1485 few or none were duly observed Thus the proposed act begins

The kinges highnes oure mooste drad and benigne soveran lorde calling vnto his good and profite memorye that dyuers and sundry beneficiall Statutis Actis and ordynauncis have bene heretofore constituted made and ordeyned wt greate advise in dyuers parliamentes aswell in the tyme of his mooste victorious reigne as in the tyme of sundry of his mooste noble progenitours for thaugmentacon mayntenaunce and good encreas of the Comon Weale of this his Realme/And by greate experience and long travaile his said highnes righ[t] well perceivithe that albeit the same Actis Statutis and ordynauncis be ymprintid and soo playnely put furthe in our maternall Englisshe tong that all his subiects may here see rede and obserue the same yet fewe or none of the said good Actis Statutis and or dynauncis bee hidderto duely obserued and bettir it were they neuer had bene made/onlesse they shuld bee put in due and profite execucon but mooste oftene whene they or any of theym happen to bee put in experience it is done of malice Rancour and evill And ouer this his mooste excellente highnes graciously hathe considred that in all Courtis of this his realme saving oonly in his high Courte of parliamente, there is neuer at any tyme any sutis matiers or causis attempted commenced and entreated of, but oonly suche as concerne meum and tuum [23]/And soo for lak of putting the said good and holsome Actis Statutis and ordinauncis in a due and charitable execucon by some good and indifferente officers thereunto to bee appoyntid according to the true meanyng entente and purpos of the same, the comon weale of this his realme susteyneth and by a long tyme hathe susteyned no little hurte and damage and seldome is regardid or lokid vnto in many and sundry partes of this realme aswell wtin liberties as wto[u]t[e]/In consideracon whereof the kingis said highnes myending nothing more undir god thene a good and charitable reformacon of all his subiectis and the reducing of theym frome thattempting of all erroures and other thinges that maye damage hindre or yn anywise preiudice his said comon weale not coveting by any meanes the losse of there goodis and substaunce, but oonly their enriching and encreas in sundry vertues and in their due obedience vnto his highnes and his lawes hath by thadvise of the lordis spuell and temporall and of the comons in this his present parliamente assembled and by the auctoritie [of] the same devised ordeyned and eustablisshed theis actis statutis and ordynauncis hereaftir ensuyng for a perpetuall encreas augmentacon and corroboracon of the comon weale of this realme foreuer in tyme to com[e]

The suggestions regarding the lack of enforcement of various and sundry statutes and the need of a more expedient execution of the law is not to be taken too seriously There was a definite change in the form of statutes under Henry VIII They increased to a prodigious length, being burdened with verbosity, frequent repetitions,

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tively little opposition was met by the commissioners for taking the oath of supremacy *Ibid*, Appendix, Nos. 24, 26

[23] "Mine and thine," a popular phrase used to express the rights of property Bacon, *op cit*, p 536, records that there was too much intermeddling with *meum* and *tuum* during the preceding reign

and perplexing, tedious details [23] Likewise, we may expect to find it observed that many acts were instituted for the "encreas of the comon weale" [24] and the "charitable reformacon of all his subiectis" or some equally noble sentiment Such phraseology may be dismissed as mere form, though in this case it happens to be partly true But we do have other evidence that there was just such a need for the closer administration of justice which this court sought to provide Lack of right order in the commonwealth [25] was increased, it appears, by the great extortions used by men of power and authority This was especially true within certain liberties and franchises From a remembrance of Cromwell "of certain business and matters in Yorkshire" in 1534 we learn that "the King's felons, murderers and outlaws are cloked, colored and maintained by stewards and bailiffs of liberties, so that the King's process has no place, and he is not answered of any profits on the said offenders, which causes his laws much less to be dreaded" [26] It is, therefore, not without reason that the jurisdiction of the justices of the commonweal is made applicable both "within and without liberties" [27] As to what acts and ordinances enacted since 1485 are here implied, we can only hazard a guess Both reigns had been fertile in legislation [28] There were seven

[23] An excellent discussion of the change in the form of the statutes under Henry VIII is given in J Reeves, *History of the English Law*, IV 558 560 (A later American edition, by W F Finlason, Philadelphia, 1880)

[24] 'Commonweal" (originally two words) was a common term in the sixteenth century and was often used synonymously with "commonwealth" Indeed it so occurs in Statute 33, Henry VIII c 10 " to the great detryment hurte and prejudice of the Cōmon Wealthe" (*Statutes of the Realm* III 841) In fact "publike weale' is sometimes used, as in 26 Henry VIII c 6 (*ibid* p 500) Its literal interpretation as here used in this document is general well being or prosperity, especially the general good of the community See James A Murray *A New English Dictionary*

[25] A volume of Clement Armstrong s treatises relating to the commonweal states this as a cause of the great scarcity of victuals and money that resulted in anguish and the vexation of the commonalty See *Letters and Papers of the Reign of Henry VIII* (1534), VII, No 1690 [26] *Ibid*, No 1669

[27] We shall see later that they are empowered to call before them persons who have infringed, broken, or violated any statute "penall or popular" within and without liberties (see p 468) This infringement of the prerogative of the Crown, ' to the greate dymynucion and detriment of the Roill estate of the same and to the hynderaunce and greate delaye of Justice,' was reformed during the next year by Act of Parliament "An Acte for recontynuyng of certayne liberties and francheses heretofore taken frome the Crowne,' 27 Henry VIII, c 24 (*Statutes of the Realm*, III 555)

[28] On the parliaments of the reigns of Henry VII and Henry VIII, see Stubbs, *op cit*, XII 305-336, and XVI 405-426

parliaments during Henry VII's reign of twenty four years, although Henry VIII held only nine parliaments in his thirty-eight years, there were many more sessions, since Parliament was prorogued several times The total number of individual statutes enacted during the two reigns would, therefore, extend into the hundreds many of them pertained to the law of the commonweal Chief among them were acts regulating and increasing the power of the justices of the peace Perhaps Henry VII's most important legislation was that directed toward the maintenance of a police control [29] This was continued by Henry VIII As Tout points out, it was the justices of the peace and the sheriffs who controlled the daily life of the average Englishman and, through his fear of the king's power, strengthened the power of the Crown rather than that of the local magnates [30] The justices of the peace met the needs of the central authority, securing the better execution of the law and glorifying the royal prerogative In every shire they were appointed by the Crown, holding their offices during the pleasure of the king and subject to heavy penalties for negligence of duties [31] In the first year of Henry VII's reign justices of the peace were empowered to examine offenders for unlawful hunting in forests and parks [32] and to warrant their arrest, in 1487 they were permitted to take bail [33] The next year an act was passed for the better administration of justice, pointing out the negligence of justices of the peace and charging them with a strict execution of their commission [34] As we have seen, Henry VIII used them as the basis of a local class, trained in the art of governing, upon which he built his rule of absolutism But it seemed that by 1534 a need was felt for a closer supervision of local justice and the enforcement of statutes Let us see how this was to be secured

"Six wise discreet and sage men of this realme," of whom three

[29] Beard, *Justice of the Peace in England* p 100 even holds this to be his most important work

[30] Tout, *op cit*, IV 68

[31] Beard, *op cit*, p 71 They might be and often were excused from serving by letters patent

[32] 1 Henry VII, c 7 (*Statutes of the Realm* II 505), *Rot Parl*, VI 335 No 74

[33] An Act that Justices of Peace may take Bayle changing the Statute 1 Richard III c 3 (*Statutes of the Realm*, II 478), 3 Henry VII c 4 (*ibid*, II 512), *Rot Parl*, VI 402 No 24

[34] 4 Henry VII, c 12 (*Statutes of the Realm*, II 537, *Rot Parl*, VI 437, No 41)

"shalbe lerned in the comon lawes of this his realme at leste being vttir baresters in Innys of Courte," [35] shall be appointed to constitute a court, sitting in the "White Hall" at Westminster,[36] having full power and authority to "ordre and fynally to discusse and detirmyne all and allmaner of matiers causes and sutis concernyng the conservacon and mayntenaunce of his comon weale" [37] They were to be called "Iusticis or Conseruatours of the Comon weale," empowered to call before them any and all persons, within as well as without liberties, who have "infringed, broken or violated any act, ordainance or statute, penall or popular," enacted since the beginning of Henry VII's reign [38]

The passage is interesting for at least two reasons, namely, that these judges are to be called justices or conservators and that it strongly suggests an act which was later passed for the proper execution of certain statutes [39] This manner of preserving the peace of the commonweal by assigning justices to make inquiries into disobedience of the laws of the land and general lawlessness dates back to the thirteenth century Stubbs traces its origin from the enforcement of a proclamation of an oath of the peace issued in 1195 under Richard I by Hubert Walter, which was committed to knights specially appointed for that purpose [40] Certainly by the time of Edward I we know that an officer called *custos pacis* was the forerunner of the justice of the peace [41] By the end of the reign of Edward II that office was fast assuming the functions of the justices of the peace in the following reign [42] Though it is not desirable to consider here the

[35] Utter barristers were ordinary practitioners who ranked next to the benchers in the earlier classification of the Inns of Court.

[36] Or, "in some other place appoyntid vnto theym by the kinges said highnes."

[37] We shall see how this rather liberal power was sustained by the separate provisions of the act

[38] Except, of course, those acts that had been repealed

[39] An Acte concerninge the Execucon of certayne Statutes. 33 Henry VIII, c 10 (*Statutes of the Realm*, III 841)

[40] Stubbs, Wm, *Constitutional History of England* (3 vols., Oxford, 1891–97), I 546

[41] *Ibid*, II 219 The sheriff was not uncommonly employed as keeper or conservator of the peace in the thirteenth century He was, for example, a very important figure in restoring peace and order from 1265 to 1267 After 1264 we find sheriffs bearing the title of "custos", fifteen were so designated in the list in the 31st Report of the Deputy Keeper, *Assise Rolls*, 20, mem 6 (8 Edward I) See W A Morris, *The Mediaeval English Sheriff to 1300* (New York, 1927), pp 175, 221

[42] Beard, *op cit*, p 28

development of that office,[43] it may be noted that after the commissions of 1307, 1308, and 1313 the powers and duties of the conservators increased from year to year[44] It is sufficient to observe that, considering the duties assigned them, we are not surprised to find our judges of the Court of the Commonweal styled conservators of the peace Nor is it any departure to find men appointed to put into execution certain laws of the realm[45] This was ordinarily done by special commission, but sometimes an act specified that the justices were to regulate its enforcement[46] In 1541/2 a special act authorized the justices of the peace at their Easter general session to put into execution certain specified statutes,[47] and by an "Acte for the due execucon of proclamacons" in 1542/3 the king appointed nine counselors to form a legal court for punishing all offenders of proclamations[48] This court of certain members of the Council has little resemblance to our six conservators of the commonweal, although the powers entrusted to the justices of the peace in 1541[49] were not unlike those of the conservators, except that they were less extensive By this act the justices are required to "holde and kepe within the lymitte of their division one Sessions beside the Generall quarter sessions for the Peace" six weeks before each general quarter sessions begins and there inquire, hear, and determine all offenses, issuing due process and judgment

[43] See the interesting mandate to R C Bigot keeper of the peace in the counties of Norfolk and Suffolk in 1264 *Calendar of Patent Rolls* (48 Henry III) Part 1, 331

[44] *Parl Writs*, II, Div II, Part 2 pp 8 9 *et passim*, and pp 74, 75

[45] Since the Statute of Winchester in 1285 (Stubbs, *Select Charters* [9th edition, Oxford, 1913], p 470, *Constitutional History of England* II 123) justices or conservators of the peace were ordinarily used for such purposes In fact so many special duties come to be entrusted to the hands of the justices that they have been described as "extraordinary" guardians of the peace (William Lambarde's *Eirenarcha* [1610] p 18) Some further light is thrown on the early functions of the justices by two membranes composing the roll of record inquests held before "custodes pacis ' in the county of Essex in Edward I (1277) and Edward II (1308)

[46] A case in point of fact is the law of 1530–31 regulating the poor and vagrant class of people the enforcement of which was put in the hands of the justices of the peace. See 22 Henry VIII, c 12 (*Statutes of the Realm* III 328)

[47] 33 Henry VIII, c 10 (*Statutes of the Realm*, III 841)

[48] 34 and 35 Henry VIII, c 23 This act was passed to secure the proper enforcement of Statute 31 Henry VIII, c 8, which gave the king's proclamations the same force as law It has often been pointed out that these two statutes consummated the king s absolute legislative and executive powers of the state This act was to continue during the king's lifetime (*Statutes of the Realm*, III 923)

[49] Act 33, Henry VIII c 10 (*Statutes of the Realm*, as referred to in note 39)

against all offenders It is to be noted, however, that in this case no new office is actually created as that of the conservators of the general peace of all the land, which we are here considering

The six conservators are not to work alone, they may appoint at their discretion in every county and liberty within the realm assistants to be called "sergeauntis or servauntis of the comon weal" to "serche and tenquyre frome tyme to tyme of and vpon all and euery the violatours brekers and offendours of any manner of Actis Statutis or ordynauncis popular or penall aforesaid not repelled being heretofore ordeyned and made for thestablishement and encreas of the Comon Weale of this realme in and sithens the furst yere of the reigne of the said mooste noble king henry the VIIth" It appears that these sergeants are specially appointed to hunt out offenders or breakers of the law that action might be taken before the termination of the three-year period allowed by the statute which rendered such prosecution illegal [50] But it was not Henry's desire that any offense whereby the ever attenuated Crown purse might be replenished should go unpunished Accordingly the sergeants were to be especially charged and sworn to "duely and truely and diligently serche and enquyre" for all offenders of any purpose or reason whatsoever against all laws or transgressions of the law [51] Whether such an office would have developed into a mere royal machine for the extraction of fines and obligations from an unwilling people, like the diabolic system employed by Henry VII's well-known agents, Empson and Dudley, we

[50] This act is rehearsed in the document as a justification for the sergeants diligent search for violators As justice was then administered, it was possible for violations to go unpunished, inasmuch as the kinges said highnes of his mercifull benignytie and goodness trusting alwayes in the refourmacon and amending of his said subiectes gave his mooste royall assente vnto a Acte made in the iiiith yere of his mooste victorious reigne There is an error however, in the citation of this act The reference is to An Act that Informacons uppon Penall Statutes shalbe made within three years" enacted in the first year of the reign instead of the fourth (1 Henry VIII c 4) The act deplores the failure of the proper execution of a 'great nombre of penal statutes and provides that all action on such statutes shall be commenced by or within three years after the offense Further stipulation is made that from henceforth all information or action upon any penal statute shall be within a one-year period (*Statutes of the Realm* III 2)

[51] It is to be presumed that the sergeants and conservators took the same oath However, neither this oath nor that of the pronotary is given On the back of the last folio (fol 38) is this heading ' The othe of the Conseruatours, ' and the following page is reserved for the oath of the pronotary or ' clerc of Counsaill ' But the oaths themselves were never filled in

have no means of ascertaining But we may be sure that neither Cromwell nor his master was the type of man to let an opportunity to increase the Crown revenue pass by unheeded That such profit was expected is evidenced by the care taken for the assessment and disposition of fines The sergeants must, within one year after the occurrence thereof, report all offenses or transgressions occurring within their jurisdiction to the conservators, who, in turn, should make process against the offenders to appear personally in their court to answer for their offense When this appearance comes, if the sergeants cannot prove their cases against the suspected person, they themselves "shall susteyne bere and paye double dammages for the costis and chargis of euery such parties for wrongfully accused " [52] The conservators, after hearing the case, may assess such reasonable fines as seem to them justifiable (a rule pliant enough in applicability) and give days and respite upon good securities for the payment of such fines All such receipts of fines, issues, and forfeitures were to be paid into the exchequer, and recognizances and arrears (sums "oute of hande or at dayes") should be estreated from this court into the exchequer twice yearly,[53] so that the barons of the exchequer may make out an undelayed process unto the sheriff of each county and liberty for the recovery of the same

The conservators are also to have a special seal for their court, which is interesting from the description of its curious engraving, it is to have

> gravid on the oon syde a shippe wt tharmes of the kingęs highneš on it, and ōn the othir side shalbe graved a plugh two hande *cartis a hamer* and a *spade* signyfying that by labour and tilling of the erthe and by the good industrye of draping of clothes and of marchauntis fishers maryners myners and of handy craftis the greate bourdene of the Cōmon Weale of this realme ymmediately and nexte undir the kinges highnoš and his nobilitie and chevalrye is and intymes paste hathe bene alweys susteyned mayntened and borne to the greate honour prouffite and enriching of all the subiectis of the same

It is significant that this symbolism is indicative of the great interest shown by the first Tudors in industry and commerce

The especial powers conferred upon this court and its council [54] would have made it an institution of great power and influence The court was to sit at Whitehall every day during the four terms of the

[52] ' Or more as it shalbe thought resonable by the said Conseruatours

[53] In like manner and form as "estreytis bee made into the said eschequer oute of the kingis high Courte of Chauncerye " the bill states

[54] We are not informed about the exact composition of the council

year, "thre houres before noñe and thre houres at aftir noñe for audience" and there hear and determine cases and all "matiers depending yn anywise before theym bitwene the kinges highneß and any of his said subiectes" It is quite clear on this point that the court should not infringe upon the jurisdiction of the common law courts or take cognizance of cases between subjects [55] If, however, the sergeants discover any offense and report it, then it shall go into the conservators' court regardless of whatever jurisdiction it may happen to be in This is likewise true of persons willfully submitting themselves to the court, when this happened the Court of the Commonweal thus automatically acquired foreign jurisdiction and none other could usurp its inherent right It was thus plainly an institution erected for the purpose of finding and hearing those cases that either escaped the attention of other courts or had never lain within the general scope of their power In the conflict of the civil law jurisdiction under the new monarchy, with its jurisprudence and prerogative courts, such an institution as the Court of the Commonweal would have added to the already existing complexity of the administration of justice [56]

The conservators may at their pleasure require all the sheriffs to return inquests to them [57] by which they may try any issue between the king and his subjects And every person impaneled on any inquest, who is warned to appear before them, making default of such appearance must forfeit such fines and issues as is customary before the justices of the assizes in their circuit When the accused is acquitted, the court shall immediately give judgment for discharge, but when he is condemned it must address process not only against the body of the litigant but also against his goods and chattels [58] But oftentimes it would obviously not be desirable or expedient to remove a case from the county where the matter lies, because justice could better be expedited locally Therefore, the conservators may direct

[55] It explicitly specified that this ordinance shall not be hurtful or prejudicial to any of the justices of the assize, justices quorum, justices of shewers, justices of the peace, "nor any enheritour, officers mayors bailiffs or others of the realm" for the punishing of any offense or misbehaviour in any of their courts or leets ("letis)

[56] See the description of the power and activity of the Star Chamber, Chancery, Requests, etc , during Wolsey's ascendency (A F Pollard, *Wolsey* [London, 1929], p 76, *et passim*)

[57] "Such enquestis sufficiente of ffree holde as shalbe mete to serue the kinges highneß "

[58] Such process was customary in all courts

writs, under the seal of their court, to the justices of the assizes, "if nede shall soo requyre," authorizing them to hold the trial of cases which would properly come within the scope of the Court of the Commonweal Such trials would occur in the respective counties according to the common law The justices, failing in due observance of such writs from the court, forfeited £10 for every default The conservators [49] may, under their seal, grant commissions to the escheators throughout all the land to make inquiry concerning all disobedience of proclamations and statutes, requiring them to report all such findings to the court within two months under pain of £20 Such commissions if used indiscriminately would virtually make of every escheator in England a sergeant of the new court It can readily be seen to what length its arms could reach when all the machinery provided for was put into execution

Yet this was not all, the conservators were given the right of making their own interpretation of personal conduct that might be considered *prejudicial to the commonweal, without specifying the statute* violated When exercised by strong judges, this power might be converted into a mere device for extracting fines from the people by the same noxious practices that had made Empson and Dudley so notorious Witness the wording of the bill in this respect

> Itm if any persone or persones shall chaunce at any tyme hereaftir wtin any counties or liberties of this realme or wtin any other place of any of the king our soueraine lordes domynions aswell in and vpoñ lande as in or vpoñ any watirs freshe or salte to doo or tattempte any devise practise or experience whiche hathe beñe is or in tyme to coñe shalbe thought vnto the said Conseruatours to bee hurtefull or preiudiciall to the Coñon Weale of this Realme, and none acte statute prouysion or ordynaunce made for refourmacon of the same/That thene alweyes and in that cace the said Conseruatours shall addresse their lettres of sub pena vnto the parties soo attempting, comaunding theym vpoñ a certaine payne personally tappere before theym in the white haule or in any other place to theym appointid as is aforesaid/And vpon their apparence the said Conseruatours shall yn nowise permitte or suffre theym to departe but dayly tenioyene theym to make their personall apparence aswell before noñe as aftir noñe vntill suche tyme as they by their othe shalhav[e] disclos[ed] of as many oth[ers] whiche they doo knowe that w[hat manne]r and fourm haue attemptid to hurte and dam[mage the] coñon weale as t haue done and alsoo shalbe contente to [50] bee bounde

[49] Five, four, or even three of the conservators may act in any legal capacity as though all six of them were present, provided "oon of theym that is lerñed in *the laws to be oon as is afore lymitted*"

[50] The passage "by their othe shalhav[e] content to," is inserted at the top of the page, as an apparent addition or correction after the paragraph had been written It is defaced and somewhat illegible, but it is the only part of the document that is at all difficult of comprehension

to thuse of the kingis said highnes by recognisaunce in such somme or sommes of money as the said conseruatours shall thinke good that they and euery of theym from hensfourthe shall leve or forbere and desiste any further tattempt intcomytte vse or medle of or in any suche practise experience or devise aftir that tyme And it is ordeyned and enacted by vertue of t[his] presente acte that all and euery recognisaunce t[aken] and knowlegid before the said conseruatours aswell in behalf as in all other matiers and causes shall sta[nd] and be good availeable and effectuell in the law[e] in euery behalf and to all ententis in like maner and forme as if they had beñe knowlegid and takeñe in the kingis high Courte of Chauncery

Was such power ever before given to one body of judges? What wonder that such a bill did not pass the threshold of Parliament when its institution might easily have revived iniquities ten times worse than those practiced by Henry VII and his ministers for squeezing money from rich and poor alike? If passed, what man might not well have cause to shudder lest he commit some indiscretion that would bring him before the Court of the Commonweal of his dread sovereign!

In order to facilitate promptness in the execution of justice, it is provided that when any party shall appear before the court and "there opeñely knowledge his defaulte and submytte hymself before the said Conseruatours vnto the will and mercye of the kinges highnes̄," they may qualify the rigor of the law, tempering justice with such reasonable fines as their discretion deems fit Those who depart from court are penalized £5, but those refusing to obey a summons to present themselves for examination shall be fined 3*s* 4*d* for their first offense, 6*s* 8*d* for the second, 13*s* 4*d* for the third, 20*s* for the fourth, 40*s* for the fifth "and soo to double as long as wyllingly and obstynatly he woll absente and wtdrawe hymself frome making of his apperence" But if the accused does not prove obstinate and presents himself in due season, he is to be given the privilege of "libertie chalenge and triall" according to the course of the common law provided for in actions of debt or trespass [61] However, when the parties are convicted and sentenced, or when found guilty of misbehavior or contempt of court, the conservators may commit them to the Fleet, where they must await the mercy of the king's pardon

The few remaining points of the bill concern matters covering the actual practice in the court and the fees of its various officers It is

[61] There is a qualifying clause in this provision "Saving that euery persone making aunswere in writing before the said Conseruatours shalbe sworne oon a boke that as moche parte of his said aunswere as concernythe his owne faite he knoweth the same to be true/And suche parte thereof as concernythe thacte or faite of any other he supposithe it to be true"

especially provided that all pleas and entries shall be made in the English language [62] The salaries of the officers are according to the customary standards of the day The conservators are to receive £100 sterling annually, the clerk of the council is to get 100 marks,[63] to be paid not out of the proceeds of their own court or that of the exchequer but out of the office of the hanaper — a practice much used by Henry VIII and his father The sergeants, on the other hand, take for their fees only such penalties as are contained in the act or proclamation violated This was doubtless a crafty device to render them more susceptible to an untiring search for likely offenders The other incidental fees of the court were not large A list of these, such as they were, must be openly subscribed in writing to hang on the wall of the court room, thus preventing any possible chicanery on the part of the officers themselves The regular fees for appearance, the entering of pleas, the taking of recognizances and the routine work of the court were here explicitly specified No sum over twelve pence was to be charged for any entry or for any one copy out of their books,[64] "be it neuer soo long," upon pain of forfeiting three times that sum or more to the aggrieved party The fee for things passing under the court seal was to be 4*d*, and the profits so accruing were to be used to sustain the charges of one or two officers to serve the conservators, who were always present in the court with them [65]

With these meager facts before us concerning the procedural form of the court, we can hardly determine what would have been its actual functions in the hands of the most powerful of the Tudors much less can we conjecture the almost unlimited possibilities to which such an instrument of control might have been directed by the crafty brain of its creator, Cromwell If we may make an historical deduction from analogy, it is reasonable to suggest that, like its predeces-

[62] They "alweys shalbe pletid spokene entrid and done in our maternall Englisshe tong and in none other language

[63] The chief officers of Henry s great revenue courts also received £100 annually, although the possibilities for exploiting the office of Chancellor of the Augmentations or that of the First Fruits and Tenths rendered the salary actually realized much greater than £100

[64] This is the only mention made of the records of the court Doubtless, if it had been developed it would have grown into another one of those great courts of record of the sixteenth century of which the Court of the Augmentations is the most salient example

[65] No further reference is made to these officers They were probably messengers of which every court at that time seemed to have a goodly number

sors, the Court of the Commonweal would soon have assumed powers and importance far beyond those expressly implied in its constitution Doubtless the device was too obvious to be realized, for the plan suffered an abortive death Cromwell's attention may have been directed to other and more pending matters, or the remonstrance of Parliament may have been such that Henry decided such an innovation in the administration of justice would be inopportune But whatever the cause, its untimely end has eliminated a long, though doubtless fascinating, chapter in the administrative history of England in the sixteenth century

UNIVERSITY OF MICHIGAN

THE POLITICAL IDEAS OF ROBERT BURNS

EVERETT SOMERVILLE BROWN

ROBERT BURNS was a keen observer of contemporary politics Although much of his best poetry is descriptive of the rural life of the Ayrshire district in which he lived, his interest in human affairs was far from being provincial Economic changes, the American and French revolutions, parliamentary elections, and the trend of European politics generally, all attracted his attention and became the subject of his pen, either in poetry or in letters

Burns's life extended from 1759 to 1796, a comparatively short period, but one full of momentous happenings in the history of mankind His own early years familiarized him with those class distinctions which were to lead to bloody revolution in France and to demands for reform in Great Britain and elsewhere He drew upon his personal experience to write as he did in *The Twa Dogs*

> I ve noticed on our Laird s court-day
> An mony a time my heart s been wae
> Poor tenant bodies, scant o' cash,
> How they maun thole a factor s snash,
> He'll stamp and threaten, curse and swear
> He'll apprehend them, poind their gear
> While they maun stan', wi aspect humble,
> An hear it a an fear an tremble! [1]

Burns's contempt for class distinction based on birth and wealth was frequently expressed in his writings, for example

> What signify the silly idle gewgaws of wealth, or the ideal trumpery of greatness! When fellow partakers of the same nature fear the same God, have the same benevolence of heart the same nobleness of soul, the same detestation at everything dishonest, and the same scorn at everything unworthy - if they are not in the dependance of absolute beggary, in the name of common sense, are they not EQUALS? [2]

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[1] *The Poetical Works of Robert Burns*, edited by J Logie Robertson (Oxford University Press, London 1926), p 41 (cited hereafter as *Poetical Works*) See also J De Lancey Ferguson, *The Letters of Robert Burns* (Oxford 1931) I 107 (cited hereafter as *Letters*)

[2] *Letters*, I 257–258, see also p 244

Upon his return from Edinburgh in 1789 he wrote

> When I must skulk into a corner lest the rattling equipage of some gaping blockhead contemptible puppy or detestable scoundrel should mangle me in the mire I am tempted to exclaim - What merits these Wretches had or what demerit have I had in some state of Pre-existence that they are ushered into this scene of being with the sceptre of rule and the key of riches in their puny fists and I am kicked into the world the sport of their folly or the victim of their pride? [3]

This feeling found its ultimate expression in poetry in his immortal verses declaring

> The rank is but the guinea stamp,
> The man s the gowd for a that

and

> The honest man tho e er sae poor
> Is King o men for a' that!

Decorations, ribbons, titles, what did they signify?

> The man of independent mind
> He looks and laughs at a that [4]

To one holding such sentiments the struggles of the common man everywhere became matters of intense interest Burns's attention was first attracted to the revolt of the American colonists by the economic effects of the war on the Scottish farmer In one of his earliest recorded letters he wrote in 1783

> This country, till of late was flourishing incredibly in the Manufactures of Silk, Lawn & Carpet Weaving and we are still carrying on a good deal in that way but much reduced from what it was, we had also a fine trade in the Shoe way but now entirely ruined, & hundreds driven to a starving condition on account of it — Farming is also at a very low ebb with us. In short my d^r Sir since the unfortunate beginning of this American war, & its as unfortunate conclusion, this country has been, & still is decaying very fast [5]

The war must have been the subject of considerable study by Burns, for in 1786 he wrote a satirical rimed history of it in which he exhibited not only a comprehensive grasp of military and political affairs, but also a keen insight into the personal characteristics of the soldiers and statesmen concerned in it This poem is usually entitled, *A Fragment When Guilford Good,* but in a few editions of Burns's poems it is called *The American War* [6] Tracing the trend of events from the Boston Tea Party in 1773 to the election victory of William

[3] *Letters* I 311 [4] *Poetical Works*, pp 328-329 [5] *Letters*, I 15-16

[6] *Poetical Works*, pp 405-407 See also *Letters*, I 25, and p 61, where references are made to the poem

Pitt in 1784, Burns wielded his poetic brush with uncanny and devastating skill Frederick North, second earl of Guilford, on whose motion the Cabinet decided to retain the duty on tea the gallant American general, Richard Montgomery, whose attack on Quebec resulted in his death, General "Tammy" Gage, shut up in Boston by Washington, General "Willie" Howe, accused of spending his time in dissipation General Burgoyne, who lost his way, ae misty day," in the woods at Saratoga, Colonel Simon Fraser, whose death was a severe blow to Burgoyne, Lord Cornwallis, "who fought as lang's he dought", Sir Henry Clinton, inactive while Cornwallis was being entrapped, George Montague, duke of Manchester, who upheld the American cause, George Sackville, known also as Lord George Germain, whose stubbornness at the battle of Minden in 1759 prevented the winning of a decisive victory, Edmund "Paddy ' Burke, champion of a policy of friendship and conciliation, Charles James Fox, gamester and opponent of the war, North, Rockingham, and Shelburne, who followed one another in rapid succession as prime minister, Grenville, first marquis of Buckingham, favorite of George III, Henry Dundas, first Viscount Melville, the political leader in Scotland, "Willie" Pitt, "Chatham's boy", — all pass in review Only a man widely read in contemporary history could have written this poem

A plea for political tolerance, made in a communication to the editor of the *Edinburgh Evening Courant* in 1788, led to a further comment on the American Revolution At a meeting in the parish church to give thanks for the blessings flowing from the Glorious Revolution in England, reference was made to "the bloody and tyrannical house of Stuart " Admitting that to the Glorious Revolution "we owe no less than our liberties religious and civil," Burns continued "Bred and educated in revolution principles, the principles of reason and common sense, it could not be any silly political prejudice that made my heart revolt at the harsh abusive manner in which the Reverend Gentleman mentioned the House of Stuart " He asked whether, in weighing the acts of the Stuarts, allowance should not be made for the manners of the times, and proper comparison be drawn with royal contemporaries of the Stuarts Burns then stated the case as he saw it, with remarkable clarity and tolerance

At that period the science of government — the true relation between King and subject, like other sciences, was but just in its infancy, emerging from

the dark ages of ignorance and barbarism The Stuarts only contended for prerogatives which they knew their predecessors enjoyed, and which they saw their contemporaries enjoying, but these prerogatives were inimical to the happiness of a nation and the rights of subjects In this contest between Prince and People the consequence of that light of science which had lately dawned over Europe, the Monarch of France, for example was victorious over the struggling liberties of the subject With us, luckily the Monarch failed, and his unwarrantable pretensions fell a sacrifice to our rights and happiness Whether it was owing to the wisdom of leading individuals or to the justlings of party, I cannot pretend to determine, but likewise happily for us, the kingly power was shifted into another branch of the family, who, as they owed the throne solely to the call of a free people could claim nothing inconsistent with the covenanted terms which placed them there

Man Mr Printer, is a strange weak, inconsistent being – Who would believe, Sir, that in this our Augustan age of liberality and refinement, while we seem so justly sensible and jealous of our rights and liberties, and animated with such indignation against the very memory of those who would have subverted them, who would suppose that a certain people, under our national protection should complain not against a Monarch and a few favourite advisers but against our whole legislative body, of the very same imposition and oppression, the Romish religion not excepted, and almost in the very same terms as our forefathers did against the family of Stuart! I will not, I cannot, enter into the merits of the cause, but I dare say the American Congress, in 1776 will be allowed to have been as able and as enlightened, and a whole empire will say, as honest, as the English Convention in 1688 and that the fourth of July will be as sacred to their posterity as the fifth of November is to us [7]

The lessons of the American Revolution were not lost on Burns, and he drove them home to the governing class in his *Address of Beelzebub*, wherein His Satanic Majesty sneeringly gibes at the attempt of the Highland Society to prevent five hundred Highlanders from seeking escape from feudal ties by migrating to Canada

Then up amang thae lakes and seas
They'll mak' what rules and laws they please,
Some daring Hancock, or a Franklin
May set their Highland bluid a ranklin ,
Some Washington again may head them,
Or some Montgomery fearless lead them,
Till God knows what may be effected
When by such heads and hearts directed,
Poor dunghill sons of dirt and mire
May to Patrician rights aspire!
Nae sage North, now, nor sager Sackville,
To watch and premier o'er the pack vile,
An' where will ye get Howes and Clintons
To bring them to a right repentance,
To cowe the rebel generation,
An' save the honour o' the nation? [8]

[7] *Letters*, I 270–271, see also pp 273, 277

[8] *Poetical Works*, p 226

Burns also combined the particular subject of the American Revolution with the more general theme of liberty In a letter of June 25, 1794, to Mrs Dunlop, he wrote ' I am just going to trouble your critical patience with the first sketch of a stanza I have been framing as I passed along the road The subject is LIBERTY you know, my honored friend, how dear the theme is to me I design it as an irregular Ode for General Washington's birthday " [9] The bard sings

No Spartan tube, no Attic shell,
  No lyre Aeolian I awake,
'Tis liberty s bold note I swell,
  Thy harp, Columbia, let me take!
See gathering thousands while I sing
A broken chain exulting bring
  And dash it in a tyrant s face!
And dare him to his very beard
And tell him he no more is feared
  No more the despot of Columbia's race!
A tyrant s proudest insults braved
They shout, a people freed, they hail an empire saved!

In the course of the description of the degeneracy of kingdoms everywhere, Burns interspersed these lines

But come ye sons of Libertie
Columbia's offspring brave as free!
In danger s hour still flaming in the van
Ye know and dare maintain the royalty of Man! [10]

J G Lockhart, in his *Life of Robert Burns*, relates that according to neighborhood tradition Burns "gave great offence by demurring in a large mixed company to the proposed toast, 'the health of William Pitt,' and left the room in indignation, because the society rejected what he wished to substitute, namely, 'the health of a greater and a better man, George Washington '" [11] Whether this incident actually occurred or not, the story, printed as early as 1828, is assuredly in harmony with Burns's expressed political sentiments

It was but natural that the French Revolution should make an appeal to Burns He was somewhat hampered in his expression of opinion of it by the fact that he held the office of exciseman, and,

[9] *Letters*, II 246

[10] *Poetical Works*, pp 260–261

[11] Pp 302-303 The story has been frequently repeated by other writers among them John Drinkwater in his play *Robert Burns*, p 105

moreover, he had a growing family dependent on him Writing to Mrs Dunlop on December 6, 1792, he said

> We, in this country, here have many alarms of the Reform or rather the Republican spirit, of your part of the Kingdom - Indeed, we are a good deal in commotion ourselves, & in our Theatre here 'God save the king ' has met with some groans & hisses, while Ça ira has been repeatedly called for — For me, I am a *Placeman*, you know, a very humble one indeed, Heaven knows, but still so much so as to gag me from joining in the cry — What my private sentiments are, you will find without an Interpreter [12]

Burns's political principles were called into question, however, and in his explanation to Robert Graham, who was one of those instrumental in securing for him his appointment as exciseman, he declared that he had not participated in any demonstration against the King of England or in favor of revolutionary doctrines He stated, however, that, so far as reform principles were concerned, while he looked upon "the British Constitution, as settled at the Revolution, to be the most glorious Constitution on earth, or that perhaps the wit of man can frame," at the same time he thought that there had been a good deal of deviation from the original principles of the Constitution, "particularly, that an alarming System of Corruption has pervaded the connection between the Executive Power and the House of Commons" He added "As to France, I was her enthusiastic votary in the beginning of the business — When she came to shew her old avidity for conquest in annexing Savoy, &c to her dominions, & invading the rights of Holland, I altered my sentiments " [13]

The same change in sentiments is seen in his verses On one side stands his short poem *On General Dumourier's Desertion from the French Republican Army*, [14] on the other, his rimed challenge, *Does Haughty Gaul Invasion Threat?* [15] Lockhart and other biographers tell a number of interesting stories of this phase of Burns's life, but they are omitted here because they are not referred to directly by Burns himself A long poem, *The Tree of Liberty*, devoted to the French Revolution, has been the subject of much controversy Auguste Angellier definitely credits Burns with the authorship of it, but Burns's more recent and careful biographers deny that he ever wrote it [16]

[12] *Letters* II 137
[13] *Ibid*, pp 143–144, see also p 169
[14] *Poetical Works*, pp 463–464
[15] *Ibid.*, pp 368–369
[16] Compare Auguste Angellier, *Robert Burns* (Paris, 1893), II 203–205, and

After the outbreak of war with France partisan spirit ran high and Burns became involved in difficulties as a result of proposing the toast "May our success in the present war be equal to the justice of our cause" He characterized this as "a toast that the most outrageous frenzy of loyalty cannot object to" [17] He had read many times Dr John Moore's *View of Society and Manners in France, Switzerland and Germany*, and had also perused the same author's *Journal during a Residence in France* Moore was a royalist in his sympathies and Burns, referring to the execution of Louis XVI and Marie Antoinette, wrote that he could not "approve of the honest Doctor's whining over the deserved fate of a certain pair of Personages" It was the welfare of millions of people which appealed to him [18]

Burns characterized politics and religion as "two master-subjects for your Sayers of nothing," [19] yet both subjects interested him greatly In domestic politics one of his earliest activities was an appeal to William Pitt on behalf of the distillers of Scotland, published in the *Edinburgh Evening Courant* on February 9, 1789 It was claimed that the Scotch distillers had been ruined by a tax which favored English distillers who had great influence in Parliamentary elections Burns disclosed considerable practical knowledge of contemporary politics in his remark "The little Great Man who drives the Borough to market, and the very Great Man who buys the Borough in that market, they, two, do the whole business, and you well know, they, likewise, have their price" [20]

But Burns did not rest his cause here In *The Author's Earnest Cry and Prayer to the Scotch Representatives in the House of Commons* he made a lengthy rimed appeal on behalf of the distillers which was a masterpiece of satire and fun A few choice bits follow

Tell them wha hae the chief direction,
Scotland an me's in great affliction
E'er sin' they laid that curst restriction
On aqua-vitae,
An' rouse them up to strong conviction,
An' move their pity

The Poetry of Robert Burns, edited by W H Henley and T F Henderson (Edinburgh, 1896), IV 107 [17] *Letters*, II 249

[18] *Ibid*, pp 281-282 Dr John Moore (1729-1802) became one of Burns's patrons and correspondents. It was for Moore that Burns wrote his long autobiographical sketch, see *ibid*, I 104-116.

[19] *Ibid.*, I 377 [20] *Ibid*, pp 303-304

Stand forth, an' tell yon Premier youth
The honest, open, naked truth
Tell him o' mine an' Scotland's drouth
His servants humble
The muckle devil blaw ye south
If ye dissemble!

Yon ill tongu'd tinkler Charlie Fox
May taunt you wi' his jeers an' mocks,
But gie him 't het my hearty cocks!
E'en cowe the cadie,
An' send him to his dicing-box
An' sportin' lady [21]

Shortly thereafter, on April 3, 1789, Burns informed Mrs Dunlop that he had finished a "political Squib," adding "Politics is dangerous ground for me to tread on, and yet I cannot for the soul of me resist an impulse of any thing like Wit" [22] The "political Squib," a copy of which was inclosed with the letter, was his *Ode to the Departed Regency Bill* [23]

Inability to "resist an impulse of any thing like wit" was disclosed in another letter to Mrs Dunlop on April 4, 1789, wherein he referred to the thanksgiving for the restoration of the king to health as "a solemn farce of pageant mummery," [24] and inclosed a copy of a letter which he had sent to the editor of the *London Morning Star* With the letter to the editor went a poem, *A New Psalm for the Chapel of Kilmarnock (On the Thanksgiving-day for His Majesty's Recovery)*, the general tone of which may well be judged by the closing stanza

Now hear our prayer, accept our song,
And fight thy chosen's battle
We seek but little, Lord, from thee —
Thou kens we get as little! [25]

One might well agree with Burns that politics was dangerous ground for him, for he was exceedingly outspoken in his references to the reigning house The poet laureate's ode, and other celebrations of June 4, 1786, the king's birthday, inspired Burns to compose *A Dream*, in the course of which he states

For me, before a monarch's face —
Ev'n there I winna flatter,
For neither pension, post, nor place,
Am I your humble debtor

[21] *Poetical Works*, pp 79–84
[22] *Letters*, I 321
[23] *Poetical Works*, pp 541–543
[24] *Letters*, I 329
[25] *Poetical Works*, pp 543–544

So nae reflection on your Grace,
Your kingship to bespatter
There's mony waur been o' the race
And aiblins ane been better
Than you this day [26]

In his lines *On Seeing the Royal Palace at Sterling in Ruins,* he blurted out

The injured Stuart line is gone
A race outlandish fills their throne
An idiot race to honour lost
Who know them best despise them most [27]

In *Awa', Whigs, Awa',* he mourned

Our ancient crown's fa'en in the dust —
Deil blin' them wi' the stoure o't,
And write their names in his black beuk,
Wha gae the Whigs the power o't [28]

The whole matter was condensed well in the *Poetical Address to Mr William Tytler*

But why of this epocha make such a fuss,
That gave us the Hanover stem?
If bringing them over was lucky for us,
I'm sure 'twas as lucky for them

But Royalty, truce! we're on dangerous ground,
Who knows how the fashions may alter?
The doctrine to-day that is loyalty sound
To-morrow may bring us a halter [29]

Burns remarked to Mrs Dunlop that he had another "Poetic whim" in his head [30] This was entitled *Sketch Inscribed to the Right Hon C J Fox,* and contained mirth-provoking gibes at Fox, as well as satirical advice for the vanquishing of William Pitt

Thou first of our orators, first of our wits,
Yet whose parts and acquirements seem just lucky hits,
With knowledge so vast, and with judgment so strong,
No man with the half of 'em e'er could go wrong,
With passions so potent, and fancies so bright
No man with the half of 'em e'er could go right,

But truce with abstraction, and truce with a muse
Whose rhymes you'll perhaps, Sir, ne'er deign to peruse

[26] *Ibid*, pp 67–71
[27] *Ibid*, p 283
[28] *Ibid*, pp 480–481
[29] *Ibid*, pp. 253–254
[30] *Letters*, I 329

Will you leave your justings, your jars, and your quarrels,
Contending with Billy for proud-nodding laurels!
My much honour'd Patron, believe your poor Poet
Your courage much more than your prudence you show it
In vain with Squire Billy for laurels you struggle,
He'll have them by fair trade, if not, he will smuggle,
Not cabinets even of kings would conceal 'em,
He'd up the back-stairs, and, by God, he would steal 'em
Then feats like Squire Billy's you ne'er can achieve 'em,
It is not, outdo him — the task is, out-thieve him [31]

Even more ranting and humorous is *The Five Carlins*, a ballad written for the election of 1789 Burns described the political situation to Mrs Dunlop in a letter of October 2, 1789

In this country we are just now Election mad — Sir Ja[s] Johnston, the present member for the Boroughs, has now opposite interests to the Great Man of this place, Queensberry — His Grace is keenly attached to the Buff and blue Party renegadoes and Apostates are, you know, always keen — My Landlord's Son, a young Officer of twenty, is his Grace's creature and is supported by the Foxites, Sir James, on the other hand, is backed by Ministerial influence — The Boroughs are much divided, and veer about with much uncertainty the *weight* of the arguments of the several Candidates will determine their success. — The Boroughs are Dumfries, Lochmaben , Annan, Kirkcudbright and Sanquhar [32]

Having thus explained the meaning of the "Five Carlins," Burns began

There was five Carlins in the south,
They fell upon a scheme,
To send a lad to Lon'on town
To bring us tidings hame.

Not only bring us tidings hame,
But do our errands there,
And aiblins gowd and honour baith
Might be that laddie's share

The Carlins argued loud and long, with honors of oratory so evenly divided that the poet concluded thus

So how this weighty plea will end,
Nae mortal wight can tell;
God grant the King and ilka man
May look weel to himsel'! [33]

Burns also alluded to this election ballad in a letter to his political patron, Robert Graham He criticized Queensberry severely, declar-

[31] *Poetical Works*, pp 250–252
[32] *Letters*, I 360–361
[33] *Poetical Works*, pp 402–405

ing that "a man who has it in his power to be the Father of a Country, and who is only known to that country by the mischiefs he does in it, is a character of which one cannot speak with patience" All in all, he disclosed a critical insight into the political affairs of each of the boroughs in question [34]

Campaign methods have not changed so very much since Burns's day In *The Fête Champêtre* he reviewed ways of obtaining votes

> Come will ye court a noble lord,
> Or buy a score o' lairds man?
> For worth and honour pawn their word,
> Their vote shall be Glencaird's man
> Ane gies them coin ane gies them wine
> Anither gies them clatter,
> Annbank, wha guess d the ladies' taste
> He gies a Fête Champêtre [35]

In other campaign ballads Burns tells of candidates who

> bent on buying borough towns,
> Came shaking hands wi wabster loons
> And kissing barefit carlins [36]

There were those also —

> For building cot-houses sae famed,
> And christening kail yards [37]

To sum up the parliamentary campaigns generally, Burns asks

> Saw ye e'er sic troggin?
> If to buy ye're slack,
> Hornie's turnin' chapman —
> He ll buy a' the pack [38]

This, indeed, is campaign "literature" with a vengeance!

Scattered throughout Burns's letters are constant evidences of his wide reading Nor was this reading confined to the field of literature Burns recognized the importance of the great contemporary works on economics and governments which came to his attention He exclaimed that "that extraordinary man, Smith, in his *Wealth of Nations*," helped to fill his leisure hours, and he remarked "I could not have given any mere *man*, credit for half the intelligence Mr Smith discovers in his book I would covet much to have his ideas

[34] *Letters*, I 370–372 [35] *Poetical Works* p 418 [36] *Ibid*, p. 203
[37] *Ibid*, p 416 [38] *Ibid*, p 418

respecting the present state of some quarters of the world that are or have been the scenes of considerable revolutions since his book was written "[39] Adam Smith's *Wealth of Nations* was published in 1776, and Burns was writing in 1789 The books were borrowed ones, and Burns reported that he would return them soon after he had given the *Wealth of Nations* another perusal [40] As a matter of fact, the poet kept the books for six months, but eventually returned them [41]

In 1793 Burns presented to the public library in Dumfries a copy of *The Constitution of England*, by Jean Louis de Lolme, with the inscription "Mr Burns presents this book to the Library & begs they will take it as a Creed of British Liberty — untill they find a better "[42] De Lolme's work was printed in Amsterdam in 1771 in French An English edition made its appearance in October, 1775, and other editions followed rapidly Burns's gift is proof not only of his own immediate interest in the broader aspects of politics, but also of his desire to see that his fellow men were given an opportunity to read worth-while books In commenting on a neighborhood library which he had helped to promote in 1791, and which contained a number of literary and historical masterpieces, he said "A peasant who can read, and enjoy such books, is certainly a much superior being to his neighbour, who, perhaps, stalks beside his team, very little removed, except in shape, from the brutes he drives " [43]

Burns at one time or another subscribed to several newspapers, and there is ample evidence that he followed political events abroad His ability to skim the news is shown in his versified thanks *To a Gentleman Who Had Sent a Paper*, the time being the year 1790

Kind Sir, I ve read your paper through,
And, faith, to me, 'twas really new!
How guess'd ye, Sir, what maist I wanted?
This mony a day I've grain d and gaunted
To ken what French mischief was brewin',
Or what the drumlie Dutch were doin ,
That vile doup-skelper, Emperor Joseph,
If Venus yet had got his nose off,
Or how the collieshangie works
Atween the Russians and the Turks,
Or if the Swede, before he halt,
Would play anither Charles the Twalt
If Denmark, any body spak o't,
Or Poland, wha had now the tack o't,

[39] *Letters*, I 335 [40] *Ibid*, p 349 [41] *Ibid*, p 372
[42] *Ibid*, II 211 [43] *Ibid*, p 90

How cut-throat Prussian blades were hingin
How libbet Italy was singin ,
If Spaniard, Portuguese or Swiss
Were sayin' or takin aught amiss
Or how our merry lads at hame,
In Britain's court kept up the game
How royal George the Lord leuk o'er him!
Was managing St Stephen's quorum,
If sleekit Chatham Will was livin
Or glaikit Charlie got his nieve in,
How daddie Burke the plea was cookin
If Warren Hastings' neck was yeukin [44]

On the score of *The Rights of Woman* may we list Burns as an early supporter of equal rights for women? Let him make his own claim

While Europe's eye is fix'd on mighty things
The fate of empires and the fall of Kings,
When quacks of State must each produce his plan,
And even children lisp the Rights of Man,
Amid this mighty fuss just let me mention
The Rights of Woman merit some attention [45]

It must be confessed, however, that the remainder of the poem is not confined to political rights, but ranges over a much wider field

Burns expressed great impatience at the impeachment of Warren Hastings

> I believe in my conscience [he wrote to Mrs Dunlop], such ideas as my country, her independence, her honor, the illustrious names that make the history of my native land, &c — I believe these among your *men of the world*, men who in fact guide for the most part and govern our world, are looked on as so many modifications of wrongheadedness They know the use of bawling out such terms to rouse or lead THE RABBLE, but for their own private use, with almost all the *able statesmen* that ever existed, or now exist, when they talk of right and wrong they only mean proper and improper, and their measure of conduct is, not what *ought*, but what they *dare* [46]

In entering his subscription to the *Edinburgh Gazetteer*, Burns wrote to William Johnston "Go on, Sir! Lay bare, with undaunted heart & steady hand, that horrid mass of corruption called Politics and State-Craft! Dare to draw in their native colors these

'Calm thinking VILLAINS whom no faith can fix —

whatever be the Shibboleth of their pretended Party " [47]

[44] *Poetical Works*, p 269
[45] *Ibid* pp 244-245, see also *Letters* II 132-133
[46] *Letters*, II 19 [47] *Ibid* pp 130-131

Complaining to Alexander Cunningham because he had not heard from him, Burns asked whether he was in the "mazes of Law, the mysteries of Love, or in the profound wisdom of modern politics" Cursing the latter word, Burns proceeded to compose the following catechism on the subject

> Quere, What is Politics?
> Answer, Politics is a science wherewith, by means of nefarious cunning, & hypocritical pretence, we govern civil Polities for the emolument of ourselves & our adherents
> Quere, What is a Minister?
> Answer, A Minister is an unprincipled fellow, who by the influence of hereditary, or acquired wealth, by superiour abilities, or by a lucky conjuncture of circumstances, obtains a principal place in the administration of the affairs of government
> Q What is a Patriot?
> A An individual exactly of the same description as a Minister, only, out of place [48]

In the same critical strain he wrote to Miss Deborah Duff Davies

> Out upon the world! says I that its affairs are administered so ill! They talk of REFORM – My God! What a reform would I make among the Sons, and even the Daughters of men! Down, immediately, should go Fools from the high places where misbegotten Chance has perked them up, and through life should they sculk ever haunted by their native insignificance, as the body marches accompanied by its shadow [49]

Easily and deeply moved by human suffering, Burns on several occasions cried out against the horrors of war "War I deprecate misery & ruin to thousands, are in the blast that announces the destructive Demon" [50] In similar vein are his lines *On Thanksgiving for a National Victory*

> Ye hypocrites! are these your pranks?
> To murder men and give God thanks?
> Desist for shame! Proceed no further!
> God won't accept your thanks for murther! [51]

He prophesied that

> For a' that and a' that,
> It's coming yet, for a' that,
> That man to man the warld o'er
> Shall brothers be for a' that [52]

[48] *Letters*, II 149–150
[49] *Ibid*, pp. 164–165
[50] *Ibid*, p 141
[51] *Poetical Works*, p 305
[52] *Ibid*, p 329

Defending the use of his pen for political purposes Burns demanded

> Does any man tell me that my feeble efforts can be of no service & that it does not belong to my humble station to meddle with the concerns of a People? I tell him, that it is on such individuals as I that for the hand of support & the eye of intelligence, a Nation has to rest The uninformed mob may swell a Nation's bulk, & the titled tinsel Courtly throng may be its feathered ornament, but the number of those who are elevated enough in life to reason & reflect, & yet low enough to keep clear of the venal contagion of a Court, these are a Nation's strength [53]

"Liberty! Thou art a prize truly & indeed invaluable!" Thus wrote Burns in reference to his immortal song, *Scots Wha Hae*, Robert Bruce's address to his army before the Battle of Bannockburn [54] "So may God ever defend the cause of Truth and Liberty, as he did that day!" [55] This fervent prayer for the preservation of liberty is the keynote of all the political ideas of Robert Burns

University of Michigan

[53] *Letters* II 171 [54] *Ibid*, p 230 [55] *Ibid*, p 195

CHINESE CLASSICAL POETRY

ROBERT WOOD CLACK

I HAVE been asked several times by people who knew of my long residence in China and of my interest in the Chinese language and literature "Do the Chinese have any poetry?" This question is called forth, I suppose, by the fact that the Chinese they have seen in this country seem so stolid and unimaginative, and also because the ordinary white considers all other cultures so far inferior to his own But we should remember that the Chinese were a highly civilized people, dressed in silks and satins and with a literature which had been developing for at least a millennium when our own ancestors were still roaming around in the woods of northern Europe, clad only in skins and without even the rudiments of a written language Ardent Chinese lovers were writing to their sweethearts lyrics that are still unsurpassed in delicacy and beauty when our ardent ancestors were wooing their sweethearts chiefly by beating them over the head with a club

As proof of that statement let me quote here a lyric that comes down to us from not later than 1000 B C , at least 3,000 years ago I have called it "Fairer than Moonlight"

> The moon comes out, enchanting, in the sky
> But far more charming art thou to my eye
> Thy quiet grace hath bound me with love's chain,
> My heart yearns for thy sweetness — but in vain
>
> The moon comes out with its bewitching light
> Far more alluring art thou to my sight
> Thy sweet indifference magnifies my grief
> My longing heart finds naught to give relief
>
> The moon comes out, in all its beauty rare
> Thou hast a winsomeness that's far more fair
> Thy loveliness hath kindled in my heart
> A burning fire that never can depart

This was written at least a thousand years before Caesar's legions had their first contacts with the Teutonic savages in the forests along the Rhine

This and the rest of the oldest Chinese poems still extant are found in the *Shih Ching*, or "Book of Odes," one of the famous Five Classics, which, with the Four Books, form the foundation of Chinese classical literature Just how old they are we do not know, but they were old when Confucius, in the sixth century B C, collected them and edited them into their present form He picked out and kept 305 from an original collection of over 3,000

It is generally impossible in translation to get the elegance and suggestiveness of the Chinese original We must know that literary Chinese (Wenli) is exceedingly terse A great deal of meaning can be packed into one word, because of its literary connotations, just as each musical note has its overtones And all unnecessary words are left out, as in a telegram The reader is to supply the context from his imagination Here is an example from an ode that I have named "Dating and Waiting"

Ching nü ch'i ch'u, Sse nge yü ch'eng yü,
靜 女 其 姝 俟 我 於 城 隅

Ai er pu chien, Sao shou ch'ih ch'u
愛 而 不 見 搔 首 踟 躕

A literal word-for-word translation of this is "Quiet girl her beauty, Wait I at city-wall corner Love yet not see, Scratch head undecided halt" Dr Legge in his translation of the *Odes* renders it thus "How lovely is the retiring girl, She was to await me at the corner of the city wall Loving and not seeing her, I scratch my head and am in perplexity" But this translation utterly fails to get the spirit of the Chinese, which is here distinctly flippant, also it is clumsy, and rhyme and rhythm are entirely lost I believe my own translation much better reproduces the spirit of the original

With a lovely bashful beauty I had a special date,
  To meet me at the corner of the ancient city wall
But despite my loving ardor I found I had to wait,
  In nervous apprehension that she wouldn't come at all

Evidently feminine nature has changed very little in 3,000 years

Most of the time during the thousand years from the days of Confucius to the Tang Dynasty political conditions were not favorable for the development of great poets In the first part of this period there was a reaction from the classical, much like our modern orgy

of free verse, and consequently little good poetry was produced. What was written was irregular in meter and careless in regard to rhyme. But there is one poem from this time which, because of its music and its philosophy, I consider one of the outstanding gems of all Chinese verse. It is "Horizons," by Sung Yü, a statesman of the third century B.C.

> Among the birds the phoenix, among the fish the whale
> Is first in might.
> The phoenix wings to heaven, the crimson clouds to scale,
> In rapid flight,
> Above the blue sky boundless, and out to space's edge,
> What bliss to soar!
> Yet to the twittering sparrow the world is but a hedge,
> And nothing more.
> The whale swims in that ocean but may to this sea come
> Before day goes,
> Yet to the humble minnow a puddle is the sum
> Of all he knows.
> And as with birds and fishes, just so we have with man
> Both small and great.
> Here soars a gorgeous phoenix, there swims leviathan
> Without a mate.
> Philosopher and poet to the Infinite give ear,
> Till life is spent.
> The vulgar crowd unthinking lives in its narrow sphere,
> And is content.

During the Han Dynasty, just before and after the beginning of the Christian Era, there was a short and glorious period when literature and the arts flourished for a time. In poetry there was a return to the classical style of the *Odes*, which have ever since remained the one standard for Chinese poetry. But seldom again do we find the humorous ballad, or the flippancy that gives spice to many of the odes. A distinctly melancholy note creeps in, which is hereafter characteristic of Chinese poetry. The Emperor Liu Ch'e (better known to history by his throne name, "Wu Ti"), of the first century B.C., was an enthusiastic patron of the arts. He also had the calendar reformed, and really accurate chronology begins with his reign. He himself had quite a reputation as a poet. I leave the reader to judge from this poem, "The Fallen Leaf," whether or not that reputation was justified. It was written on the death of his favorite consort.

> The sound of rustling silk is stilled,
> With drifting dust the court is filled,
> No footstep echoes from the floor,
> And piles of leaves block up the door,

For she I loved has gone from me
A leaflet frail dropped from the tree

The first famous Chinese poetess appears during this dynasty She was the Lady P'an, long a favorite of the Emperor Ch'eng Ti, and was noted for her virtue and her wit as well as for her poetry When she was ultimately discarded by the Emperor in favor of a younger rival, she sent him a white silk fan on which was inscribed

Oh fair white silk just woven fresh and new
As pure as snow and bright as sparkling dew
I make of you a fan for one I love
Shaped like the round moon in the sky above
Where er he goes he ll take you with him there,
To stir for him a grateful breath of air

And yet I fear when autumn s chill comes on
And dying summer s ardent heat is gone
That you will carelessly be cast aside,
When need of you like thought of me has died

Since that time the expression "autumn fan" has been proverbial in Chinese for a neglected wife

With the Tang Dynasty (from about 600 to 900 A D) we come to the Golden Age of Chinese literature This dynasty is associated in the Chinese mind with the romance of war and adventure, with wealth, culture, and refinement, also with frivolity, extravagance, and dissipation, but most of all with poetry Some idea of the enormous amount of poetry written at this time may be gained from the fact that in 1707, almost a millennium later, there was published a collection of the Tang Dynasty poetry deemed worthy of preservation, containing 48,900 poems in 900 books Is it not something for the Chinese to view with pride that at a time when Europe was submerged in the barbarism of the Dark Ages such refinement of thought and culture was current in the Celestial Empire? The *Odes* were still considered the basic standard for poetry, but there was a change in the subject-matter, as well as an increasing elegance in the way it was handled Owing to new social customs the love lyric almost completely disappeared Flowers and birds, clouds and mists, the moon and the seasons, woods and hills, wine and the waters have become favorite subjects A strain of mysticism is almost always present

Meng Hao Jan (689–740) failed at the public examinations and then retired to the hills and became a recluse He is said to have sought inspiration for his verse by riding on a donkey through the

snow on the mountains But that can hardly have been the inspiration for "On a Summer Evening"

The daylight fades behind the western mountain,
Eastward see the full round moon appear
Tis faintly mirrored in the garden fountain
Night and the time of dreams will soon be here

I sit upon the balcony to rest
And stretch my limbs, refreshed by evening dews
A lotus-scented breeze blows from the west,
I hear it rustling mid the tall bamboos

I gaze upon my silent lute with sighs
Alas there is no kindred soul to hear
With yearning heart I close my weary eyes
And dream-clad friends of other days draw near

By general consent Li Po (705–762) is conceded to be the greatest Chinese poet of all time He started early, his first published poem was a "stop short" written at the age of ten (The stop short will be explained later) Here is the poem, "To a Firefly"

The rain cannot quench your bright lantern s cool light
The wind only fans it to shine still more bright
Oh why don t you fly up to heaven so far
And twinkle there near the moon — just like a star

Like many Chinese poets, he was a gay, dissipated fellow, just as, unfortunately, not a few Occidental poets have been He was born in Szechuan, the westernmost of China's provinces, but in his early youth he had wandered as far as Shantung, the easternmost province Here he fell in with kindred spirits, they retired to the mountains and became known as "The Six Idlers of the Bamboo Brook" Their fame became such that Li Po was introduced to the emperor He was received with great favor and given a position in the Imperial Academy, but he only drank the harder He finally lost favor through the intrigues of jealous palace eunuchs, and left the court to continue his wanderings with a new group of cronies called "The Eight Mortals of the Wine Cup" His poems are of many moods Here is one which shows his love of Nature and also his wonderful gift of metaphor It is "Clearing at Dawn"

The fields are chilled the gentle rain has ceased,
On every side the springtime colors gleam,
Among the boughs the singing thrushes feast,
The fish are leaping in the limpid stream

Each floweret freshens up her powdered cheek,
  The mountain grasses in the fresh breeze sway,
And from the bamboo grove beside the creek,
  The fragments of white mist dissolve away

Perhaps not the least poetical thing about Li Po's life was his manner of leaving it His last poem was "Drinking Song," written while he was out on the river with a party of boon companions Just after composing it he attempted to scoop up the reflection of the moon out of the water with his hands, but fell overboard and was drowned Here is the song

I sit midst the flowers with a kettle of wine,
  Alone I am drinking — an action absurd
If the moon now would lend me his presence benign,
  Then here is my shadow to make us a third

But the moon cannot drink, so I toss off his share,
  And my shadow but follows my motions in vain
They can't go the pace this unfortunate pair,
  The joy that they lose thus becomes my own gain

I sing — and the moon staggers round in the night,
  I dance — and my shadow reels over the floor
In my drunken confusion we all three unite,
  I drowse, and our persons are separate once more

So we merrily live, till beside the Cloud River,
We drain our last cup, and say farewell forever

Li Po is considered a master of the stop short, a type unique in Chinese verse It is found in some Han verse, but did not reach its full development until the Tang Dynasty It is a four-line epigram, given its name because of its abruptness, though the critics say "It is only the words that stop, the sense is intended to go right on" The last line is supposed to contain an element of surprise, which suggests a new, or a changed, viewpoint We had one example in Li Po's first poem His best I consider to be "To Mount Chin T'ing"

The flocks of birds have vanished that soared about on high,
A single lonely cloud now floats past in the sky
And here I sit alone the towering mountain by,
We never bore each other — the silent mount and I

Nothing has yet been said as to the rhythm of these poems There are not different kinds of feet as in Western poetry, where the rhythm is introduced by various regular combinations of long and short, or of

accented and unaccented syllables. There is no such meter as this in Chinese classical poetry, the rhythmic effects are produced by a device impossible in any other language. Each Chinese word is a monosyllable, having a tone or pitch which is as much a part of its sound as is the succession of vowels and consonants. There are from four to eight of these tones, depending on the dialect, but for purposes of rhythm they are classified as level tones, or "flats," and as deflected tones, or "sharps," and the arrangement of these tones gives the metrical effect. Each line of poetry generally consists of from four to seven words, and the positions of the sharps and flats is very definitely set by tradition. The effect produced on the ear that is trained to detect them by this succession of tones is very pleasing. Obviously this effect is impossible in a non-tonic language.

Tu Fu (712–770) is ranked by the Chinese as second only to Li Po. Like Meng Hao Jan, he failed at the public examinations, where verse making is supposed to count heavily. He finally did obtain an official position, but was twice exiled, and eventually took to a life of wandering and devoted himself to poetry as a profession.

He wrote a beautiful appreciation of Tai Shan, "The Sacred Mountain":

> How matchless in majesty rises Tai Shan,
> The fertile domains of the Duchy of Lu
> Spread out at its base, and Heaven pours down
> Its favors on mount and its environs too.
>
> The summit of Tai Shan towers high o'er the storms,
> Where the sun always shines on its buttresses bleak,
> From below as I gaze I just make out the forms
> Of eagles that soar round its pinnacled peak.
>
> I labor on up and at last reach the crest,
> And gaze down in awe at the foothills below.
> Just how we poor mortal souls, even the best,
> Appear to the Infinite, finally I know.

The prevailing note in most of his poetry is summed up in "My Philosophy":

> From flower to flower the dragon fly darts,
> The butterfly sipping sweet nectar departs.
> Each creature is happy through life a little span,
> So let us live merrily here while we can.

Han Yü (768–824) was a statesman and philosopher as well as a poet. He also wrote a large amount of very excellent prose. After

his death the emperor honored him with the posthumous title of Wen Kung ("Prince of Literature") We have a touch of his philosophy from "Peace Comes at Last"

> Alas, how quickly fades the night so cool,
> For summer's heat has chased away the spring
> My skiff floats idly on this landlocked pool,
> With dawn the sweet-voiced wild birds wake and sing
>
> Then through the mists still lingering on the hills
> The rising sun bursts forth with rosy beams,
> A fleeting hope my dreary heart now thrills,
> As thoughts of freedom stir a captive's dreams
>
> My soul is calm my flowing tears are dried,
> Though life is sad and evil at its best
> A blessed thought All care is laid aside
> When once inside the coffin one can rest

Po Chü (772–846) was another infant prodigy, who is said to have been able to read some characters at seven months, and who took his doctor's degree at the age of seventeen He spent part of his life as a recluse, but was twice recalled by the emperor, once to be governor at Hangchow, and again to hold the same post at Soochow Since these are China's two most famous beauty spots, he may have drawn some of his poetic inspiration from their enchanting scenery I quote a fragment from "The Lute Player," which gives a succession of metaphors that will bear comparison, I believe, with any poem in any language

> On our urgent invitation her fingers stroked the lute,
> *At the splendid burst of melody emotion struck us mute*
>
> Now loudly like the dashing when raindrops pelting fall,
> Now softly like the murmur when doves at evening call,
> Now loud and soft together as when a string of pearls
> Is dropped and scattered tinkling mid a group of dancing girls,
> Now liquid like the warbling of orioles in May,
> Or trickling like the brooklet that dances on its way
>
> Then like a raging torrent is stilled by winter's frost,
> The music lulled a moment, in deepest passion lost,
> And then as water gushes from out a shattered vase,
> Or on the horseman's armor is crashed the heavy mace,
> She plucked the strings again and to her music bent,
> And the lute cut through the silence like the slash when silk is rent

Chang Chi was a younger contemporary and friend of Han Yü, noted for his scholarship He died at the age of eighty, after having

been for years a tutor in the Imperial Academy His most famous poem, of which the critics say, "The beauty lies far beyond the words," is his "Reply of a Virtuous Lady to a Gift"

You know that I am wedded sir not free
Still these two costly pearls you send to me!
Your boldness comes from heart by love possessed,
Your pearls now lie concealed upon my breast

And yet — our house is held in high regard
My husband is a captain of the guard
I feel a man of honor such as you
Will know that I to virtue must be true
With your two pearls I send you back twin tears
Of sorrow that we met too late in years

Since the time of the Tang Dynasty every Chinese scholar has been taught verse writing as a part of his education, but it has been a polite accomplishment with little or no inspiration, and most of the poems disclose an artificiality which leaves the reader cold and disappointed But still this lack of quality in the mass of poetry makes a few real gems stand out even more sharply in contrast

Ch'eng Hao (1032–1085) was chiefly noted for his prose writings on serious subjects Every man must relax sometimes, and Ch'eng is responsible for this flippant little skit, "The River Banks"

I roam at pleasure north and south, and stop where er I will
I see the river banks grow sere from autumn s breezes chill
But if gales blast the river banks, why should I greatly care?
The color of the river banks is the river banks' affair

Another better known as a statesman than as a poet was Yeh Shih (1150–1223) "The Rebel" is a stop short at its very best

The verdant park is closed against the trampling crowd,
No gateman comes to answer our knocking long and loud,
But all of springtime's beauties can't quite be shut away,
For o er the jealous wall projects a pink-flowered almond spray

It will be noted that almost all these poems are short The long poem is not relished by the Chinese (Is it relished by the West, either?) There is no such thing as an epic in the language The ideal lies not in what is said, but in what is suggested, and it is considered that a maximum of twelve lines is enough to suggest any worth-while thought The stop short is the logical product of this ideal

The Chinese are exceedingly fond of rhymed couplets, a favorite indoor sport of scholars is for one to give a line of original poetry to

which another must add a line which caps the idea, or pay a forfeit There must be not only rhyme, but a parallelism between words in corresponding positions in the two lines Most of the scrolls hung up for decoration carry matched couplets of this type Here is an example from the *Odes*

> The hawk soars, attaining the heavens,
> The fish dives, reaching the depths.

Then there is the famous "White Sceptre Ode," with these two lines

> Pai kuei chih t'ieh, shang k'e mo yeh
> 白 圭 之 玷 尚 可 磨 也
>
> Sze yen chih t'ieh, pu k'e wei yeh
> 斯 言 之 玷 不 可 爲 也

Here four of the eight characters are the same in both lines The poem means

> The flaw in the white jade sceptre is easily ground away
> But the flaw in the words I have spoken will sound on forever and ay

In the Yüan and Ming dynasties (14th to 17th centuries) most Chinese literary men directed their best efforts to the novel and the drama The most famous poet was Fang Shu Hsiao, who died in 1642 He seems to have been a harum-scarum youth who, like Li Po and others, frequently drank too much for his own good When he felt death approaching, he had himself placed in his coffin (a coffin is always kept ready in well-ordered Chinese households), and, calling for writing material, he rested the paper on the edge of the coffin and wrote this "Poet's Last Farewell," dropping back dead as he finished

> A home awaits me where is peace in store,
> Why should I hesitate or fear to go?
> A few more fleeting hours of life below
> Are hardly something one should struggle for
> In that eternal home there'll be no more
> The need to fight against a treacherous foe,
> Why strive to linger in this world of woe,
> Where joys soon fade and ills down on us pour?
>
> Above my grave will blow the fragrant breeze,
> 'Twill not disturb my sleep in this last bed

The moon will cast long shadows through the trees,
  Whose rootlets form a tent about my head
Put pen and ink inside my coffin strong
If lonesome I ll compose another song

There is a group of poems which seem to come from this same period, when the last native Chinese dynasty was rapidly going to its fall, some of them may have been written even after the Manchus had seated themselves on the Dragon Throne I got them from Japanese sources The names of the authors were not given, but I am sure that some of them are from the brush of Wang Shih Chen, though I have not yet been able to make positive identification He lived from 1634 to 1700, and is generally credited with being the greatest Chinese poet since the Tangs He was especially famed for his excellent rhymes Into "The Wind and the Willow" there is woven a delightful little conceit which quite touches the heart

Beside the stream the weeping willows trail
  Their branches in a cloud of emerald spray
A horseman stops beneath the leafy veil,
  He breaks a plume and rides along his way

The gentle breeze of spring with plaintive song,
  Pursues him as he waves the graceful frond,
For she has been the willow's playmate long
  And cannot bear to lose a friend so fond

This poem, "A Spring Night," is pure melody

Fragrantly full of the spring, the night breezes languidly blow,
Through the bamboos an odorous mist floats up from the garden below
The flowers and the foliage are white in the silvery light of the moon,
Their shadows flit gracefully round like dancing girls swaying in tune

On tiptoe I wander entranced mid a maze of magical bowers
I push through the lacy bamboos and cautiously peep at the flowers
Under the wide-spreading fronds, where moonbeams through crevices seep
To see in the hush of the night if the delicate blooms are asleep

"The Nightingale" gives a beautiful example of fitting the words to the effect the poet wishes to produce

The summer house lies deeply set
  In leafy arbors fresh with dew
Where butterflies and bees coquette
  With blossoms fair of every hue,
Their colors bright gleam through a net —
  The lacy fronds of green bamboo

I wait alone, 'tis afternoon,
  A hush pervades the drowsy air
I close my leaden eyes, and soon
  With head bowed down I slumber there

All daytime colors disappear,
  On dreamland's paths I stroll along,
Then with a start I wake to hear
  A nightingale burst forth in song

In "The Ghosts of the Sea" we have something very appropriate for Halloween

In the hush of the night now the wind on the sea lies asleep,
Not a ripple is heard, all lies dead in the silence so deep
'Twixt the eyes on the prow of the junk shines a signal light red
Let me dream by the rail while the stars gleam so bright overhead

And I fancy I see the huge spirits of heroes of old,
Swinging maces and swords clad in helmets and armor of gold,
They come forth in the dead of the night from forgotten sea graves,
They march past with inaudible steps on the face of the waves

Eerie fires of St Elmo are blinking and flitting around
And weird tones from the bells of a temple far off faintly sound,
But no other disturbance mars darkness and silence so deep,
It is midnight and ghosts are awake while the world is asleep

And *The Melancholy Autumn* gives a good idea of what a Chinese poet can do when he really wants to be melancholy

The autumn is not mine alone and yet
  My dismal soul is filled with thoughts so gray,
That I can almost make myself forget
  It comes to others when it comes to me

The sadness of the autumn eve imparts
  Its tone to all one sees and all one hears,
I think of all the sorrows of all hearts
  And from my eyes unchecked gush forth the tears

The swallows southward wing their weary flight,
  The honk of wild geese fills the sombre air
And flocks of crows, as ebon as the night
  Quarrel noisily among the branches bare

Now like a ghostly echo from the past
  The temple bell tolls forth its doleful tone,
Across the paper windows dark are cast
  Long eerie shadows from the lonesome moon

The cricket's dull monotonous refrain
  Comes from the withered weeds outside the door
I hear a cry as from a bird in pain
  And then a silence fills the gloom once more

In these translations the lines are made to rhyme They also rhyme in the original, or once did Unhappily the pronunciation of many of the words has changed so that they no longer rhyme We have a good example of this in English in the first two lines of Chaucer's *Canterbury Tales*, where "sweet" and "root" are made to rhyme Of course, in the original they are "swote" and "rote" But in Chinese the distressing thing is that since the time of Confucius only those rhymes are allowed which are found in the *Book of Odes*, and that limits a poet to one hundred and six combinations of sounds An attempt to use other rhymes, no matter how perfect to the modern ear, brands the poet as unorthodox and illiterate I understand, however, that there are some young rebels of New China who are writing some very excellent poetry based on modern pronunciations

There are various line combinations in the rhymes, as in English, but no blank verse In general, in my translations I have made no attempt to follow the original rhyme schemes, my ideal has been to produce in English verse the same effect as that which the Chinese would give to the Chinese ear I have tried to use only English verse forms Perhaps the most frequent combination in the Chinese is the four-line stanza in which the first, second, and fourth lines rhyme The earliest place I know of where this occurs in English is in Fitzgerald's translation of "The Rubaiyat of Omar Khayyam" Perhaps there are other examples I have not seen I understand that Fitzgerald imitated the rhyme scheme of the original Persian It would be interesting to know whether this form of verse originated independently in both China and Persia

I shall close with two short poems by Lin Sung Pai, a modern Chinese, who was educated in America and who lived for some time in New York City They are written in classical Chinese style

His "Fallen Flower Petals" lends itself to a translation very near in its terse suggestiveness to the Chinese original

Flowers were these, once beautiful and sweet,
  Wooed were they by bee and butterfly
Loveless and forlorn, beneath our feet,
  Romance now is gone — in shame they die

And, finally, a stop short, "My Immortal Soul" Remembering the definition that was given, "It is only the words that stop, the sense goes right on," let us see whether we think Lin Sung Pai has here reached that standard

Oh soul! you are to life as smoke is to the flame,
  For when the fire goes out you also disappear
Yet when I see the moonbeams shimmering through the pane,
  And then the glass I break — the moon shines still more clear

ALMA COLLEGE
ALMA MICHIGAN

AN INTRODUCTION TO THE CRITICAL APPRECIATION OF LITERATURE

CARL E W L DAHLSTRÖM

TO CONSIDER literature from the standpoint of critical appreciation presents no less a task than the establishment of a literary aesthetic Although we must assume an experiential background of research, criticism, and appreciation, with all the possibilities of value inherent in each, we cannot easily make a beginning with any one of these as a basis Moreover, a sentimental harmonizing of these three divisions in the study of literature, in a vain endeavor to attain the mythical golden mean, will prove equally fruitless We desire the values of all at the same time that we wish to discard everything that is irrelevant Consequently, we shall have to reach not only behind all matters of aesthetics but even behind all human activities in the search for a valid archeformula When that is secured we may proceed with logical developments in all possible directions

BASIC CONSIDERATIONS

Every philosophy is founded on a primary postulate that must be constant as long as the system of thought continues to be valid To attain the highest values, such a postulate should not be peculiar to an individual province of human activity, but should embrace all provinces The one archeformula necessary to all systems of thought and actually inherent in them may be framed in these words Continuation in life is of value to the individual and to the species [1] Simple and commonplace as it may be, we must recognize that *survival* is unquestionably the basic constant for all thought and activity Daily we subscribe to it in our pursuit of sustenance and shelter, for we know that without survival there is neither activity nor thought Yet we are not satisfied merely to exist on the basis of minimum essentials, we want to live more abundantly Consequently, an immediate

[1] To speak of *value* with regard to human activity obviously precludes consideration of the element of self-destruction, which is the denial of value

derivative of the primary constant is the enhancement of survival Clearly, this enhancement is possible only because we possess leisure, that is, we have at our disposal time in excess of that required for the satisfaction of the immediate needs of the body [2] There is, of course, no categorical imperative regarding the expenditure of so-called free time in activities of enhancement Indeed, the only imperative is found in the conditions imposed upon us for continuation in life Not only must we provide sustenance and shelter for ourselves, and maintain health, but, in addition, since we are organisms, we must be active As a result, there are alternatives for the use of free, or spare, time It may be employed in activities for the purpose of increasing the guarantee of survival, or, it may be expended in activity *per se*,[3] either because we must continue actively in life [4] even when there are no wants to satisfy or because we long to escape from the pressure of responsibilities in the struggle for existence To increase the guarantee of survival is to give enhancement function to activity, to indulge in activity *per se* must be termed the play function [5]

In survival and the two derivative functions, enhancement and play, we run through the whole gamut of human activities as values [6]

[2] Casual observation of animal life, brute and human, should have taught us long since that activities are to be interpreted in terms of forms and functions of time expenditure We then should have comprehended leisure in its deepest significance rather than in its most superficial manifestations

[3] The order of materials does not indicate any precedence of enhancement over activity *per se* It is, indeed, difficult to assign priority to either one of these derivative functions We may be tempted to believe that the struggle for existence would place a primary stress on enhancement, but it is doubtful that evidence can be adduced to support such a view Some animals seem to take no heed for the morrow while others strive to enhance the economic guarantee of survival for a season or more

[4] We do not fail to recognize that some individuals are practically inactive when they have spare time at their disposal Such existences, however, are more vegetal than animal and time expenditure alternates between survival activities and quiescence

[5] There is no opposition between two prominent theories of play viz that which posits play as activity *per se*, and that which defines it in terms of surplus energy The latter is simply an explanation of the necessity of activity *per se*, especially in the case of children, who usually expend neither time nor energy in survival activities Life requires activity, and if the child or adult expends no time in survival or enhancement activities he necessarily engages in activity *per se* See also W P Bowen and E D Mitchell, ' The Philosophy of Play,' *The Theory of Organized Play*, Chapter IX

[6] Although activity *per se* seems to be flight from purpose, it is still a requisite for existence and thus possesses value as a derivative survival function which we call play Essentially there are no forms of activity wholly peculiar to the play

Through a preservational economy [7] and reproduction we manage to cling to life, both as individuals and as a species, by means of religion, philosophy, art, science, and all forms of socialization we struggle to enhance the value of survival beyond the limits of a day or a season — indeed, even beyond life itself — and, through all forms of activity engaged in *per se*, we continue of necessity to employ our time or else temporarily we put aside the burden of the struggle for existence

In referring to these three divisions as functions, or purposes, interdependent and closely related, we indicate that function is common to various forms of activity We are, in truth, in agreement with Morris Cohen when he says "It is thus the function of rational science as of art, religion, and all human effort to liberate us from the charnel house of the actual and reveal to us the underlying order which governs the wider realm of possibility " [8] Through survival activities we guarantee as far as possible the so-called actual that is, life itself Through activities directed toward the enhancement of survival we attempt to objectify a closer grasp of reality by reaching through the actual toward control of that "underlying order ' with all its implications of possibility Moreover, all these activities may assume the play function when they are employed *per se* [9] Manifestly, function is a common denominator for all forms of activity [10]

The basis of our work lies, then, in the comprehension of the necessity of this prime constant of survival, and the possibility of the two derivative functions of enhancement and play Upon these we may hope to erect the superstructure of thought for any province of activity, regardless of its form [11]

function Those which appear to be thus peculiar to play are unquestionably derivatives from activities which have had function in survival and enhancement It should be understood, moreover that all forms of activity having survival and enhancement function are readily developed *per se* with the play function

[7] Activities providing sustenance and shelter, and maintaining health

[8] *Reason and Nature*, p 69

[9] Some of the contemporary objections that "the play spirit has been taken out of play ' in our regimentation of recreation are well taken Stress on health, rewards, trinkets, and publicity have made it almost impossible for players to enjoy games as activities *per se*

[10] If function is common to a number of activities we logically assume an interrelationship among these activities Religion, philosophy art, and science are different ways of grasping and expressing the one sole ' underlying order

[11] Excepting, of course, self-destruction and other forms of activity in kind See note 1 above

THE PROVINCE OF ART

There should be no disagreement over the assignment of the prime function of survival to economic and reproductive activities More-over, we should experience no difficulty in reaching the conclusion that religion, art, philosophy, and science are not requisites for immediate survival,[12] though they may attain value in enhancement or in play,[13] the two alternative functions In other words, these fields of activity may provide means not only for the objectification of a closer grasp of reality but also for the expression of activity *per se*

With the functional positions in this scheme of things agreed upon, we may now attempt to differentiate the provinces Clearly, we cannot separate art from other fields of activity through evaluation of function which is a common denominator [14] Materials are little more useful Common to all forms of art is the employment of a basic substance or material as, for example, stone, line and pigment, sound, and word The basic material also serves as the medium for secondary materials, that is, attributes of sense, emotion, imagination, intellect, and spirit [15] All these materials, however, both primary and secondary, are common to several provinces rather than peculiar to art As a result, the hope of major differentiation through

[12] Without impairing the logic of this statement we may grant that the priest, the artist, the scientist, and the philosopher may earn their daily bread through activity in the province of which each is a spokesman Each is, of course, a parasite, trading his services toward enhancement for the survival contributions of others.

[13] Or in both There can be little doubt but that the play function pervades many if not all our so-called serious activities The common feeling that play is a referent solely for expressions of triviality is wholly unwarranted The products of genius always reveal a subtle integration of activity for enhancement and activity *per se* The recognition of this dual rôle in function undoubtedly led Schiller to assign such a high value to play

[14] When E F Carritt, *The Theory of Beauty*, p 3, repeats the old incantation, "Aesthetics are for aesthetics sake," not only is he evading the work he set out for himself but he is also, unconsciously no doubt, too insistent that art has only an approach to a play function See also W P Ker, *Form and Style in Poetry*, pp 182–183 At this point we may well insist that, so far as human activity and thought are concerned, nothing really exists for its own sake Even activity *per se* must imply that *man* is the important factor

[15] Dualists would probably not object to the employment of the term "spirit," nor would they question its reality as a human attribute. Some would reject the word entirely Others probably will be inclined to regard the term as a possible integrating symbol or sublimation of the more tangible attributes. Since artists confessedly struggle for an expression of spirit, an aesthetic must admit this attribute into the discussion

materials fades away, even though we recognize them as determining factors for the establishment of genres within the field of art

There is still another means of definition, that of medium [16] In religion, for example, we do not hesitate in declaring that *God* — or, the concept of deity — is the medium through which man struggles for a grasp of reality in terms of spiritual values In science a grasp of objective reality is made possible through *number* as a medium leading toward enumeration, measurement, and classification Likewise, in philosophy it is through the medium of *logic* that ideas take form and beget values Without number, science is unthinkable, without a concept of deity, there is no religion, without logic, philosophy is only abracadabra In art, too, there must be a medium without which art cannot be conceived [17]

Neuhaus tells us that "the element at once the most universal

[16] Aristotle provided a means by the adoption of the cue word Since this word is undefined and obviously not limited to *imitation*, it is of little more value to us than a mathematical unknown We do not accept *imitation*, for it is not medium, rather, it is both function and a description of the art product Moreover, if the function of art is to imitate nature or anything else what may be the purpose of so direct a copy? Aristotle, indeed, indicates a grasping for the inimitable when he tells us that ' Polygnotus depicted men as nobler than they are, Pauson as less noble", and then he approximates imitation when he says that "Dionysius drew them true to life " There is, in effect no desirability of imitation, so far as art is concerned For the creative mind the object to be used as a guide for an artistic composition always has something of the fetish about it, and it is this elusive characteristic that the artist seeks to objectify, whether or not he carries along in his work the strictly objective pattern of the original subject The artist is much like the primitive who carved out of wood an image of his god, not for the clumsy design of materials but for catching the god in a fixed form Note, too, how the expressionists in modern times have frantically set themselves against objectivity in the vain hope that through the principle of distortion they may capture pure reality Someone has aptly said that the artist does not seek to imitate Nature but to emulate her, does not desire to copy her, but to rival her See also T A Cook, *Spirals in Nature and Art*, Chapter VI

[17] We may, with reason, militate gently against a common practice of aestheticians. Unlike Aristotle, who at least used mimesis as a key modern philosophers of art fail to provide a suitable means of unification for the disparate elements which they discuss in their treatises. Moreover, they do not seem to be in harmony with Oswald Spengler's dictum that there is no such thing as art because there are many arts (see *The Decline of the West* German text, I 285-6, 293, English, I 221, 227) Without a significant and peculiar unifying element the various subfactors of an aesthetic too frequently may be used to define developments in mathematics and in mechanical drawing For example, the terms ' balance," "proportion," "harmony," and "design," are not of special significance to art alone If we fail to accept Spengler's point of view and insist that all arts are gathered into the generic term ' art, ' then surely we must seek and find a unifying mother-factor

and most pleasurable in art discloses itself in the aesthetic manifestation we call rhythm" It "is an almost indispensable quality in the artistic formulation of an idea"[18] Why Neuhaus uses the word 'almost" in the second sentence when he has already described rhythm as "the most universal" element in art is inexplicable[19] If it is the most universal element it is unquestionably that which is indispensable, the *sine qua non* of all art There is, indeed, no other single element in art that can serve better as medium than rhythm[20]

It is one thing to select rhythm as the medium of all art, it is quite another matter to prove by definition that rhythm is the all-inclusive, indispensable factor Fortunately, we are not also required to define the media of other provinces, for they are all strikingly insusceptible of definition[21] What, indeed, are number, logic, God, and rhythm? The best that we can hope to do with any, or all, is to give a symbolic index We may circumscribe them with qualifying factors and thus apprehend meaning even though we fail in explicit definition[22]

The first word that comes to us as having connotative value in the definition of rhythm is "movement" Rhythm is, in fact, much like the fire and water of Heraclitus, "an unceasing process of flux" To be that, however, it must include within itself the antecedent factor of *force*, or the source of movement Moreover, an unqualified state of flux does not satisfy our understanding of rhythm We think in

[18] *The Appreciation of Art* p 148 Note that whereas rhythm is a manifestation of nature as well as of art, rhythm-as-medium is peculiar to the province of art

[19] Turning to an artist instead of a critic we find John Galsworthy making the following comments ' But this essential quality of Art has also, and more happily been called Rhythm And what is Rhythm if not that mysterious harmony between part and part, and part and whole, which gives what is called life, that exact proportion, the mystery of which is best grasped in observing how life leaves an animate creature when the essential relation of part to whole has been sufficiently disturbed And I agree that this rhythmic relation of part to part, and part to whole -- is the one quality inseparable from a work of art" From "Vague Thoughts on Art' in A M Brooks *Readings in Art Appreciation*, pp 7-8

[20] In the space of this paper it is impossible to report on the process of testing various elements Moreover, the development of the concept of rhythm should indicate rejection of other terms which might be suggested as prime factors

[21] See for example, the second chapter in Bertrand Russell s *Introduction to Mathematical Philosophy* or, for that matter, all attempts to define the media mentioned

[22] See C K Ogden and I A Richards, "Definition," *The Meaning of Meaning*, Chapter VI

terms of movement, but also of the possibility of *infinite variation* in movement Still further, since we have posited the search for reality in terms of an "underlying order," we must also admit *law* as a conditioning factor As a result, we obtain not only *direction* in movement, but *unity in variation* as well Through law and infinite variation we likewise elicit all the other factors so common to the terminology of aesthetics to wit, *order*, *balance*, *symmetry*, *proportion*, *harmony*, and other variations of the same elements Similarly implicit in law and infinite variation is the necessity for a prime stress, or focal point, in rhythm [23]

Finally, we must complete this symbolic index to rhythm by a statement of *scope*, range, or magnitude Number limits the range of science to the objective world, to that which may be enumerated and measured, religion likewise is limited to that which is spiritual or subjective Logic holds sway over both subjective and objective worlds, but it is supposedly as rigorous as number in excluding the native play of all the connotative attributes,[24] except that of intellect Indeed, despite its range, logic is closer to number than it is to rhythm [25] It is undoubtedly because of the great inclusiveness of its medium that art has been acclaimed so frequently as the finest of human gestures Rhythm, unlike the other media, admits all the attributes of both the subjective and objective worlds as materials for aesthetic representation Sense, emotion, imagination, intellect, and spirit, in combination or in permutational arrangement, are objectified, without diminution of potential values, in stone, on canvas, in sound, and in word through the medium of rhythm

As factors of rhythm we have then the following movement, initial force, direction, infinite variation, unity, prime stress, and all else that is brought into being by means of unity in variation We note, however, that rhythm itself is not substance, is not function, it is not even tangible *per se* It is like electricity, or life itself, in that we become aware of it only through objective manifestations of its effect

[23] See Neuhaus *op cit*, p 159 regarding "the rule of the golden section"

[24] The illusions of the senses and emotional reactions and stresses *per se* are vigorously avoided by number and logic The intellectual attribute reigns supreme and definitely limits the potential range of the other attributes

[25] See C J Keyser, *Mathematical Philosophy*, p 32 Mathematicians however — like the rest of us — are not all in agreement See also J B Shaw *Lectures on the Philosophy of Mathematics*, especially Chapter V, 'Logistic and the Reduction of Mathematics to Logic'

That is, we are aware of rhythm only when, through its office as medium, materials are already gaining function

For a still clearer grasp of rhythm let us consider it in one of its most unmixed forms, the dance [26] Here it is almost *das Ding an sich*, bearing the least material burden, wordless, soundless, and almost devoid of residue [27] It attains whatever extension and intensity it has purely through its well-nigh stuffless pattern of movement, which we apprehend through the dancers in action The dance is, moreover, the clearest test of play as activity *per se* Obviously, rhythm in the dance is not simply medium giving direction toward enhancement, the content, substance, is so light that we move in the direction of rhythm *per se* In other words, every orchestic performance in its approach to immateriality moves from stress of the enhancement function into stress of play The more the dance takes on content and endeavors to objectify a grasp of something, the more we tend to call it artistic, [28] the more the dance is freed of content and approaches pure rhythm, activity *per se*, the more we are inclined to view it as play [29] We add another word to our symbolic index of rhythm when we speak of it in terms of the dance

Objections may be raised on the grounds that architecture and sculpture, and possibly painting, are altogether too static to invite any orchestic concept of rhythm At the same time, in spite of the objections, we recall that we have heard the cathedral of Chartres described as "frozen music", [30] Michelangelo's *Moses*, as "full of repressed movement, and vibrating with wrath and passion", and

[26] The product of the color-organ is an equally valid example

[27] Through moving pictures we can now objectify the dance in permanent form and thus preserve that which in earlier days would have been lost forever and consequently wholly without residue At the same time, however, our objectification, like the dance itself, is presented in movement

[28] The dance is an art form with the widest bearings on life and death procreation, war and peace, worship, etc , whether it functions as enhancement or as play

[29] See D H Parker, *Human Values*, p 308, who speaks of the dance as lying ' on the borderline between play and art " See also note 13, above

[30] We need not take seriously the pique of H V Magonigle, *The Nature, Practice and History of Art*, p 61 "Architecture was once described as frozen music, and the world has gone on repeating the phrase like Pretty Poll, architecture is no more frozen music than it is frozen mud, there is nothing frozen about good architecture, it is warm and human, full of the movement that is Rhythm, full of color and springing life ' Magonigle is unnecessarily disturbed about the continued use of the expression "frozen music" He should be aware, however, that those who repeat the words are not so concerned with temperature as he seems

Leonardo da Vinci's *Last Supper*, as a "dramatic painting" We do not use these descriptive words and phrases in vain, or with any real divagation from actuality, we are simply declaring in one way or in another that rhythm is the dominant characteristic of even the most static representations [31]

The orchestic manifestation is most patent in architecture of the baroque and rococo styles In the rococo materials become almost weightless, transparent in value, with the result that once more we are borne rapidly toward rhythm *per se* Rococo may be described fairly accurately as the dance of lines and stuff with a minimum employment of connotative attributes In painting, probably Corot comes the closest to what we call the aesthetic dance of materials, whereas, in the post-impressionists we have all too frequently a manifestation of dance largely in its play function [32]

No form of art is so static that it does not represent the objectification of materials through rhythm Again, no form of art is so dynamic in expression that it loses all objective qualities Indeed, even the dance, or the product of the color-organ, manifestly attains some objectification to gain value in either enhancement or play, or in both We place the dance in the category of play function, not when it has actually become rhythm *per se* — an impossibility — but when it has thrown off all materials except the dancers and the connotative attributes of sense and emotion It is through this progressive etiolation of content that the dance becomes an activity *per se*, while rhythm only approaches medium *per se* [33]

to be They are simply saying what Magonigle himself sets forth in the last clause quoted above, namely, that architecture is music and rhythm caught and held in fixed objectivity

[31] Note that Magonigle, *op cit*, p 23, makes rhythm an all pervading element "Rhythm is a system of accentuation of certain parts or elements of a Design to produce, in Architecture Sculpture, or Painting the equivalent of musical Rhythm, or measured movement such as we see in dancing It is also an arrangement of lines and masses in such relations as to produce the effect of a flowing transition from one line or mass to another In Figure Painting or Sculpture another form of Rhythm, and only one of the many, would be ar arrangement of the lines of the bodies, limbs, and drapery so that the lines or the masses of light and shade flow into each other, or repeat each other, and tend to unite, or tie together in the professional phrase, the entire composition '

[32] With regard to the weightless thought in impressionism see Dahlström, "Hallström s Impressionism as Illustrated in 'A Secret Idyll, ' as cited in the Bibliography

[33] We should observe that forms of activity universally classified as play activities are always light in content

We are thus brought close to the frequently expressed idea that the materials of art are obtrusive, that they are burdensome and limiting to expression There is, of course, no gainsaying the complaint The stone does impose limitations on the artist, so, too, sound and word, line, surface, and pigment obtrude upon the artist's freedom In like manner, with equal justice, we may say that experience, with its formidable array of prejudices, is an impediment to creative thought We must bear in mind, however, that *ex nihilo nihil fit* Without a background of experience, which is necessarily prejudicial, no thought is possible, for a *tabula rasa* is no mind It is far more apposite to declare that experience, prejudicial as it must be, offers substance for thought [34] In like manner, the materials of art are requisite to aesthetic expression

We have materials, medium, and function as essential to every form of human activity To complain about any one of them as burdensome or limiting and to try to free oneself from one or all is sheer vanity [35] The artist can only repeat Brand's formula, "All or nothing", for, unless he may have all necessary means at his disposal, he is powerless to do anything There is, clearly enough, a strong element of irony in all creative work To attain function, the artist must have materials and must employ a medium, but the medium is constantly threatening to absorb materials and transmute them into an airy nothingness or throw them off, at the same time that the materials are resisting medium Therein, however, also lies the secret of genius the ability to crystallize materials in medium, to force substance through rhythm into objective representation that will have value [36]

[34] Those zealous critics of the social order who ask for a sweeping away of all prejudice really do not mean what they say Substantially, they want us to examine the foundations of all our prejudices to reject all that are burdensome or destructive to progress, and to accept only those supported by sufficient evidence Cleaning the Augean stables is perhaps a necessary task, but the Alpheus and Peneus should be purifying and not annihilating

[35] Witness Rudolph Blümner's folly of "absolute poetry' The word is emasculated until Blümner naïvely creates tuneful nonsense syllables for his so-called poetry But all that appears under the guise of verse is not necessarily poetry Blümner, in reducing the word to sound values, has not freed himself and attained high expression as he hoped, he has only limited himself to materials of such little weight that his product is only a playful, orchestic performance For an example of absolute poetry see A Soergel, *Dichtung und Dichter der Zeit* p 618

[36] The complaint against materials and against rules is largely defensive mechanism coming into play when it is not ignorance or adolescent fervor The defeated or impotent artist is rationalizing the situation to his own exculpation

If, in conclusion to this section, we were required to define art in a few words, we should have to adopt for the present a formula somewhat like the following Art is a secondary province [37] of human activity, functional both in the enhancement of survival and in play It stresses enhancement, a grasp of reality, through the rhythmic objectification of the materials of human existence, taken in various combinations and permutational arrangements As art approaches activity *per se* and substantially lightens the connotative burden of its materials, it becomes pattern-making having a play function [38]

We have consciously omitted discussion of the beautiful, the ugly, and the sublime So far as these terms describe materials admitted into rhythm they are all valid, for the scope of the medium is limitless When, however, the terms are applied to the objective representation, the art product, they refer to final values In the latter usage, beauty is the necessary result and the sublime a possibility, when materials have been subtly molded into form through rhythm [39] The ugly, on

When materials and medium are in conflict and resolution seems impossible the child-artist attempts to chastise materials and medium in much the same way that a child man kicks an object over which he has stumbled With *law* posited as a factor in rhythm there is no possibility of attaining function through the complete disregard of all existent and all possible rules Lack of law always has a complementary angle in lack of unity, and chaos is the necessary result It is not of course that we must accept rules blindly and live under them servilely, rather we must test our laws constantly until the probability of error has been brought close to nil Furthermore, we must be steadily at work uncovering what still lies hidden in the wider realm of possibility , for every human effort becomes effete when discovery ceases to add materials and means Rules and materials impose limitations it is true, but more pertinent is the fact that they are the sole means we have for the attainment of function and value Note a pertinent illustration in another province that of education Widespread has been the notion that discipline — rules — should be pushed aside in favor of individual interests, desires, and even whims The abandonment of a tyrannical and blind discipline was justified, but the forsaking of all rules has been a violation of life and society both of which are constantly conditioned by law The way to freedom in all fields is never by evasion of rules but by means of them "If you want to work without rules first follow every rule"

[37] That is not requisite to immediate survival

[38] This is close to a restatement of an earlier definition (see Dahlstrom, *op cit* note 1) In the present work, however, the "intuition of reality' is rejected in favor of the concept of enhancement, that is, direction toward a grasp of reality whether it be intuitive or otherwise

[39] Caricature, which stresses the play function, is at times a sinistral approach to enhancement It is a conscious distortion of rhythm through its employment of incongruences As a result, beauty cannot be attained When, however, a grotesque is only a fractional part of a large work it may give added stress to beauty through contrast

the contrary, if not purposeful caricature, is the product of unreconciled and clashing materials and medium

A LITERARY AESTHETIC

With this skeletal outline of the province of art as distinguished from other fields of human endeavor, we are in a position to focus our attention more directly on literature If we proceed with this study as a logical continuation of the foregoing discussion, we should develop a literary aesthetic somewhat as follows First, we must reckon with the major literary forms, or genres Secondly, it is necessary to analyze and evaluate materials In the third place, we must study a work of literature as the objectification of materials in rhythm Finally, there must be adduced means whereby function may be indicated and a scale of values attained It should be clear, however, that the analysis of any one of these divisions is contingent upon a consideration of all the others

The major divisions in literature are poetry, prose, and drama [40] Common to all three is the employment of the *word* as material the word with all its values of sound and syllable, with all the implications of phrase, clause, sentence, and other rhetorical devices, with all the connotative attributes of sense, emotion, imagination, intellect, and spirit Poetry and prose are on common ground in that they employ the *word* exclusively [41] Drama, however, is literature and something more, for it employs not only the word as used in both poetry and prose, but also materials that are common to architecture, painting, sculpture, music, and the dance [42] With drama readily set apart, by virtue of difference of materials, our immediate problem in literary forms is to establish tangible differentials for poetry and prose

The separation of these two literary genres is best accomplished by an analysis of materials in rhythm [43] The poet, on the one hand,

[40] There are, of course, genres within genres, and combinations as well, but they are not of great consequence to this introduction

[41] We grant that poetry may be read aloud, chanted with a musical accompaniment, sung, and dramatised The *word* as material already admits oral values in the attribute of sound The employment of extra-verbal aids, however, simply stresses the fact that we have a mixed, or impure, form of poetry

[42] Even in the reading of a dramatic text we feel the necessity of imaginative enstagement for appreciation The written drama is, indeed, closely related to the score sheets of musical composition

[43] Though by no means in agreement, prosodists all make more or less capital of meter, temporal and spatial units, sound values, diction, etc

desires to mold all his materials into form — even to the very syllables of the word — by means of a cumulative, recurrent pattern [44] The prose writer, however, is aiming primarily at larger units of the word, and he is even careful to avoid the recurrent, patterned molding of syllables for fear that such use will obtrude upon representation of the so-called thought-rhythms The word-as-stuff in the orchestic sense is unquestionably more patent in poetry than in prose In the latter, it is thought-as-stuff that takes on orchestic significance Thus we may speak of a novel like Hudson's *Green Mansions* as poetic prose, even though there is no versification as such, because thought is minor, whereas attributes of sense, emotion, and imagination are given major stress So, too, much of the phrasing in contemporary fiction may be regarded as a vain attempt to deal with poetry and prose at one and the same time, without, however, a nice comprehension of values [45] In like manner, free verse approaches prose when the poet attempts to use the thought-rhythmics of prose for stress on sense, emotion, and imagination [46] As the word attains the recurrent, patterned objectification of poetry through the medium of rhythm it may become scintillating in qualities of sense, emotion, and imagination, but invariably it also tends to become light and vagarious in its burden of idea, or the attribute of intellect [47] The larger, non-recurrent patterns of prose, on the contrary, permit added weight of idea without necessary loss of values in other attributes It may, indeed, be said that in poetry, more than in prose, there is an easy approach to activity *per se* [48]

With the genres barely indicated, we turn to the problem of the

[44] See I Abercrombie, *Principles of English Prosody*, pp 30-36

[45] There is no question but that some of the mixed forms of literature are far more effective than some of the so-called pure forms Hudson s *Green Mansions*, from the standpoint of literary art, is a gem as compared with Morris *News from Nowhere* Moreover, the drama the most impure of all literary genres has possibilities for the highest values Purity and impurity may be tests for genres, but they are not necessarily conditioning factors for values

[46] See W M Patterson, *The Rhythm of Prose* pp xii, 87 88, 98

[47] Note that in the works of Shelley, and possibly of all philosophical poets the burden of thought is often symbolized to vacuity, and we are left largely with an emotional residue or ' high feeling " It is no wonder on the other hand that poetry explicit in thought is usually on the borderline of prose

[48] This may account for the untrammeled emotional reaction to beautiful poetry as opposed to the mixed reactions to prose In the latter case the mind is so frequently challenged by ideas that emotions cannot hold sway *per se* Ideas are backstage in poetry, but in the full blaze of light in prose

word-as-material There are two divisions to this part of a literary aesthetic first, considerations of text, and, second, matters of interpretation

The establishing of a pure text is of paramount importance whenever any doubt exists regarding the work at hand [49] A piece of literature that has been abridged, revised, expurgated, "improved," or modified in any way by an editor, except for the purpose of reëstablishing the original text when only fragmentary or corrupt versions are extant, is on a par with those works of painting and sculpture that have been retouched and beplastered to make nude figures "presentable" Moreover, though translations are to be admitted as convenient and important instruments in literature, the text in the original language must forever remain the basis for final appraisal

In the matter of interpretation we move from word to phrase, to sentence, and to larger units until we have reached the whole in the endeavor to establish meaning Within the text we find the readiest means of interpretation in all that can be elicited from the rhythmized word with regard to the attributes of sense, emotion, imagination, intellect, and spirit, and it is the work of a critical appreciation of literature to reëstablish as fully as possible the conscious, or the subconscious, intent of the artist For the purpose of interpretation there are also ancillary factors lying outside the text proper Biographical information may contribute much, so, too, the commentaries of the artists [50] themselves and of critics Moreover, a literary aesthetic must add as coadjutors to interpretation all the following knowledge of society, history, economy, government, ethics, religion, science, geography, other arts [51] — indeed, a rather inclusive knowledge It is not, of course, that all these factors are of value for the interpretation of each individual work of literature They are included as necessary to the whole scheme of things, for, whatsoever the medium of rhythm will admit as material, an aesthetic cannot deny as pertinent to interpretation

[49] Consider, for example, the ten thousand and more manuscripts of the New Testament, not one of which is an original

[50] It is scarcely necessary to mention that these cannot always — perhaps not often — be accepted at face value For example, we do not believe Ibsen when he tells us that *Peer Gynt* is not a satire

[51] In kind and out of kind The whole field of research in comparative literature is linked with this factor Note moreover, that the critical appreciation of literature invites consideration of *all* values social, scientific, religious, and philosophical, as well as those generally referred to as aesthetic

The third large province of critical appreciation is that of analysis of the aesthetic object, that is, a study of the representation given to us by the artist after he has attained objectification of materials in rhythm By means of our study of rhythm it has been made clear that certain factors must be analyzed and appraised, namely (1) the initial force — that is, situation or its equivalent (2) movement, direction, and the pattern of variations — or, in other words, plot or sequential equivalent, (3) means of attaining unity in variation — that is, harmony, symmetry, balance, proportion, prime stress, etc , and (4) scope, or inclusiveness

At this point we should observe that the study of the representation has the character of an analysis of materials in flux, for form is a continuum of content There is, in truth, no real separation of content and form as we study the aesthetic object We have at hand a content-in-form in which the most obvious manifestation will be that of conflict of medium and materials, or the resolution of such opposition [52] It is actually as impossible to remove form from content as it is to separate a facet from a jewel, or to abstract the content from a sonnet, and still have the complete form remaining [53] Consequently, the analysis of factors of representation will, as already declared, be tantamount to a study of elements in movement

The fourth province, that of function and relative values, must partake of all the foregoing analyses Obviously, the final worth of a piece of literature will be dependent on a synthesis of the values secured during consideration of matters of text and interpretation, of the objective representation, [54] and of the significance of function The setting up of a final scale of values, however, is not within the

[52] Galsworthy s *Indian Summer of a Forsyte* is an excellent example of a resolved conflict, whereas the uncertainty of movement in *A Modern Comedy* indicates clash

[53] This does not, of course, nullify our study of parts or of the mechanics of composition A study of Titian's draughtsmanship, for example, is no index to the aesthetic form of one of his paintings, but it may reveal the cause of failure or success in attaining form

[54] We may take space for a footnote, if not time in reading, to point out an index to value in the matter of situation Conflict may be born within or among the various laws governing our actions to wit physical, organic social, divine, and individual (or ego) codes Obviously, a situation based wholly on matters of etiquette (in the social code), for example will scarcely offer the possibilities of value inherent in the conflict raging when the individual man is battling against his organic fate or his spiritual destiny In other words the value of a literary work is immediately conditioned by the selection of the fundamental situation,

range of this introduction Rather, values should be the concluding section to the study of critical appreciation

We have presented foundations for the critical appreciation of literature, and also the bare outlines of the superstructure In the further development of this work it will be possible not only to reconsider positions taken earlier, but also to become more explicit regarding the manifold factors of analysis, especially those that pertain to materials in rhythm Finally, a firm foundation may be laid for a scale of values based on logical appraisal rather than on the sole testimony of time and the vagaries of individual tastes and judgments of particular eras

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or motivating force Clearly enough the mere employment of a powerful situation does not stamp a work with the hallmark of high value, for, a botching artist can spoil the most noble materials while a genius may lend an atmosphere of greatness to matters of secondary importance Naturally, value depends not only on the nature of the fundamental situation but also on the ability of the artist to handle the conflict Further see C N Wenger, *The Implications of Plot in Literature* pp. 543–554 of this volume

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AN ELEMENT OF THE VOCAL ART OF EDMUND KEAN AND DAVID GARRICK IN SHAKESPEAREAN RÔLES

AMOS R MORRIS

THE history and tradition of Shakespearean rôles, as created by a long line of great actors, are in many ways as interesting as the plays themselves This interest in the actor's art lies close to the heart of the whole matter with which drama and dramatic criticism have to do Oscar Wilde was certainly wrong in his bitterly satirical comment upon the actor's art as "terribly creative" Drama is, I suppose, the greatest of the literary arts chiefly because, though the writer of drama has at his hand all the resources of the other literary forms and puts down as much upon paper as can be put down in words, he yet leaves the job only half done, to be rounded out and completed by the inspired actor The dramatist's greatest glory lies I should think, in the inspiration he gives to the actor in the creation of his rôle

Shakespearean scholarship has not done too much of textual and historical research upon the plays and the theater, it certainly has done too little to re-create the really vital aspects of the drama as a play Fully half the field of Shakespearean scholarship remains virtually unexplored, almost nothing has been done to discover the subtler features of the actor's interpretation, upon which the charm of the play largely rests From Schlegel and Gervinus to Wallace and Hotson we have piled up a veritable mountain of valuable information and helpful comment upon the historical aspects of Shakespeare's plays, every shovelful of these factual data was abundantly worth digging up It all helps us better to understand the play as living, pulsing art, and it is, besides, absorbingly interesting stuff to set our students to pawing over in the process of developing what we euphoniously call scholarship If it has made something of a hodgepodge of our prevailing romantic criticism, it has at least put a founda-

tion of fact under the emotional structure of idealization raised by Coleridge and De Quincey and their kind.

These subtler features that have to do more directly with the fine art of the stage, the nuances of mood, and the flash of emotional insight, are of course more elusive — and by the same standards more valuable — than are the facts of text or stagecraft with which we have chiefly busied ourselves. The casual bantering give-and-take that must have daily enlivened the Mermaid Tavern would give us today invaluable hints upon what went over and what did not quite get across in one actor's portrayal of Falstaff, let us say, and in another's. We have, so far as I know, virtually nothing of this for Elizabethan times, a little for the Restoration period, a bit more for the eighteenth century. And in spite of all the dramatic criticism of our own day, it is not going to be easy for the future to understand the differences in technique of Irving, Mantel, Sothern, and Barrymore, because we do not very well understand them ourselves. Our dramatic criticism, of which we have reams every week, might be much better than it is if our critics knew just a little more of the art they talk so volubly about and so were able to see upon what slight differences in stage business and voice quality success or failure turns.

We have not yet developed an adequate technique for interpreting the actor's vocal art, even in the part that we can catch in a phonograph record. I have been interested to see professed lovers of the drama listen to Marlowe's *Juliet* on the balcony and try to decide at what pitch and range of the scale they hear the vocal melody

> If any of my kinsmen find thee here,
> If they do see thee, they will murder thee.

Do they hear it with "they will" at the crest of the melodic cadence, or an octave lower, or two octaves lower, or somewhere between? The fact itself, of where "they will" is pitched, is interesting and important for two reasons. It bears upon the fundamental question of the function of melody in speech and involves a phonetic problem of tone control. But of more importance still is the question of the validity of her technique as an artist, because there is here an emotional tension sufficient to disturb seriously her normal vocal control.

In this richest of the actor's resources, his quality of voice, we have tragically little evidence for any of the long line of great actors. When the general meaning of the line is sufficient, lack of detail is

not serious, but when subtleties of character are involved, the lack is fatal In a general way the need varies directly with the dramatic tensity of the situation We feel no compelling need for more detail in Hackett's description of Macready's *Hamlet*, since only the general meaning is in question

Mr Macready s emphasis and intonation of the word "southerly, I am but mad north, north-west, when the wind is southerly, I know a hawk from a hand-saw were such as to imply to a listener that when the wind may be from the south the atmosphere is clearer than from the north north west whereas the very reverse, according to Shakespeare elsewhere, is the fact

But when the depth and character of emotion are chiefly involved, we must have finer detail before we can judge the quality of the characterization A case in point is Bell's description of Mrs Siddon's *Lady Macbeth*

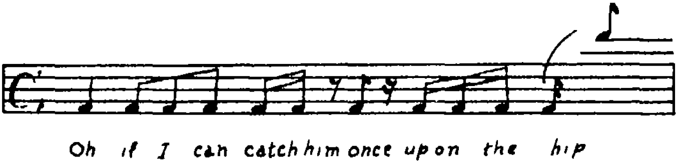
I have given sucke and know
How tender 'tis to love the babe that milks me

"Mrs Siddon at this line has been at a distant part of the stage She now comes closer to him — an entire change of manner, looks for some time in his face, then speaks" That is excellent so far as it goes, but it is chiefly stage business, her richest dramatic resource, the quality of her voice, is not mentioned, and that is chiefly what matters

The more we think of it the more we are likely to agree with Furness in the Variorum of *Antony and Cleopatra* "When Gardiner in his *Music of Nature* gives, in musical notation, the fluctuation and emphasis of Kean's voice in certain sentences, he does more to transmit the great actor, as a living presence, to succeeding generations than folios of emotional impression" The description of "the fluctuation and emphasis of Kean's voice" which Furness praises so enthusiastically is really definite only in the natural key of Kean's voice ($B^\flat$) and his speaking range of two full octaves

He has at his command the greatest number of effects, having a range of tones from F below the line to F above it, the natural key of his voice being that of $B^\flat$ a note lower than Talma's. His hard guttural tone upon G is as piercing as the third string of a violincello, whilst his *mezzo* and *pianissimo* expressions are as soft as from the voice of a woman

Gardiner then goes on to illustrate Kean's "hard guttural tone" pitched one note below his natural key, on $A^\flat$, at a frequency of about 100 d v s



That gives rather a definite clue to the fluctuating tempo in the *quarter, eighth, and sixteenth notes,* in the pauses and the phrasal division indicated by tied eighths and sixteenths The notation gives no clear evidence of the "emphasis of Kean's voice," though we can make some shrewd guesses at it from the tempo, pauses, and phrasal divisions The notation is chiefly valuable, in fact, as a guide to more intelligent guessing than, in the benighted state of criticism generally, we could otherwise do How much indeed we should like to have as good a notation as this of his reply of Shylock to the assurance of Bassanio about the bond As Gardiner reports it

> Shylock leant over his crutched stick with both hands, and, looking askance at Bassanio said 'Three thousand ducats? paused bethought himself, and then added
> 'Well? '
> He is safe!" said Dr Drury

Now that, I submit, is extremely good, but some of the other things we should like to know about the speech are these

Where in Kean's available range of two octaves did he pitch it?

What was the pitch range of his "three thousand ducats"?

What were his fluctuating stress emphasis and tempo?

With what pitch and tone quality did he imply his hesitation in what is here punctuated as an interrogation?

He "paused," Gardiner says, "and bethought himself" What was the length of the pause, how did the closing cadence of "ducats" and the beginning intonation of "well," again marked as a question, serve to accentuate his feeling of indecision?

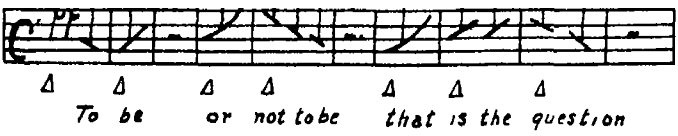
And finally, how were all these resources so used upon the "well" that the kindly disposed Dr Drury settled back in his seat in the pit with a half-suppressed ejaculation of relief, "He is safe"?

If all that seems over-refined and too much trouble to take with a little thing, the obvious answer is that only the discriminating and

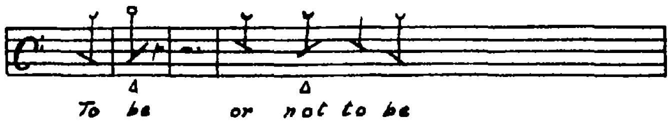
intellectually curious needs take any trouble about it at all, the ninety and nine can get all they want without it

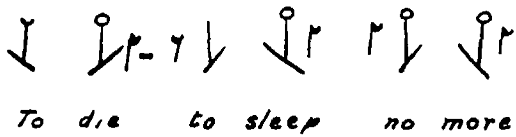
Since Furness perceives so clearly the significance of Gardiner's account of Kean's vocal technique, it is not easy to account for his entirely overlooking a still more detailed and helpful account of David Garrick's art as given by Joshua Steele in his *Prosodia Rationalis*, published in 1775 Furness could scarcely have missed seeing, at some time, Boswell's reference to Steele's recording of Garrick's voice, by which method he wishes Johnson's voice ' might be transmitted to posterity *in score* " To one who conceives his function to be that of a voice crying in the wilderness, this ignorance of Steele among Shakespearean scholars is disheartening His book as a whole is one of those revolutionary documents that ought to have set the world right but didn't, like Coleridge's *Biographia* in criticism and Henry George's *Progress and Poverty* in economics

In illustrating his method of recording the measure and melody of speech, Steele says

> It is so many years since I saw the tragedy of *Hamlet* performed that I have no remembrance of the expressions sufficient to enable me to set the following speech in the manner of any great actor but as it was one of those which I made my experiment upon with the bass accompaniment, I shall set it down as I pronounced it

After some interesting comments upon his theory of bass accompaniment on the ancient stage, he goes on

> Since writing the foregoing treatise, I have heard Mr Garrick in the character of Hamlet, and the principal differences that I can remember between his manner and what I have marked in the treatise are as follows In the first place that speech or soliloque which I (for want of better judgment) have noted in the stile of a ranting actor swelled with *forte* and softened with *piano* he delivered with little or no distinction of *piano* or *forte* but nearly uniform, something below the ordinary force, or, as a musician would say, *sotto voce* or *sempre poco piano*

Secondly as to measure, the first line thus

Thirdly, as to accent and quantity, thus



> The words, "as flesh is heir to" he pronounced as I have marked them in my variation, where the two syllables, "heir to," are both acuted, and by the modulation give the idea of the sense being suspended for the thought which immediately follows

It is interesting to note that Sothern gives this last in the same way, but gives the rising inflection on "no more" as Steele had it in his original notation

Garrick's *Hamlet* is here more nearly complete than is Kean's *Shylock* in that we have the glide of the tone and the stress indicated in three degrees The swelling of *forte* and the softening of *piano* give to the reader the sort of guidance a composer of musical score makes use of After some comment upon another phrase in a later scene, Steele goes on to supplement his notation upon Garrick's manner

> This essential quality is chiefly owing to the speaker's dwelling with nearly uniform loudness on the whole length of every syllable, and confining the extent of the accent, acute and grave, within the compass of four or five tones.

This range of four or five tones is a detail worth special note It explains, I think, why the voice of the English actor is, in our day, so much more pleasing to an American ear than is the voice of the English lecturer, or for that matter the Englishman in ordinary conversation, the actor is the heir of the Garrick tradition of a century and a half, the lecturer is the heir of a much older tradition to which the Englishman is still accustomed, but from which American English has entirely broken away The Englishman in ordinary conversation

and on the lecture platform runs a whole octave, whereas the American runs four or five tones

Gardiner's keen interest in finding the basic law which he conceived as underlying all the arts and furnishing a foundation for a scientific aesthetic would certainly have led him further in the same direction if he had lived a hundred years later and had the benefit of our relatively refined technique for studying tone effects How much more might we have had about the Restoration stage from Samuel Pepys if he had been as intelligently curious about the actor's technique as were William Gardiner and Joshua Steele The stage was a passion with Pepys, and his admiration for Betterton's acting was beyond measure If Pepys' enthusiasm for Betterton's *Hamlet* had led him to transcribe some of the more telling speeches as Gardiner and Steele have transcribed Kean and Garrick, we should have something near a Shakespeare's *Hamlet* Betterton was coached in the part of Hamlet by Sir William d'Avenant "in every particle of it" after the manner of Taylor of the Blackfryers, whose *Hamlet* D'Avenant had seen and greatly admired before the closing of the theaters Taylor of the Blackfryers had been coached in the part of Hamlet by Shakespeare himself Betterton was therefore in direct and virtually unbroken vocal descent from Shakespeare That Pepys might easily have so transcribed Betterton's speeches is attested by his mastery of music, of which we have abundant evidence All he needed was the intellectual curiosity to demand the same sharp discrimination in the art of speech as in the art of song But such intellectual curiosity is not common, only two or three rare souls have had that, even down to our own day

University of Michigan

THE ESSENCE OF FRENCH THOUGHT DURING THE EIGHTEENTH CENTURY

EUGÈNE F. ROVILLAIN

IN SPITE of the great number and the relative value of the ideas discussed by the writers of the eighteenth century and in spite of the frequent contradictions in aspirations and conclusions, which are inevitable, given the temperament of each author, there nevertheless emanates from the work of all writers a striking impression of unity. To mention the ideas they held in common, to discuss the fundamental sentiment that animates them all, is to explain the literature of this period, its hopes, the goal of its thought.

There have always been thinkers who have rebelled against the civilization of their time. They have accused it of impeding man's natural development, of thwarting him in his right to happiness by keeping him from attaining his full intellectual and moral stature. Unable to transform the prevalent conditions of their age, these restless spirits took refuge in dreams and utopias. The end of the seventeenth century and all the eighteenth century, both the cultural offspring of the Italian and French Renaissance, tend also toward utopian setting and thought in their effort to express the new aspirations of humanity.

Public opinion, in agreement with the opponents of the ruling classes, demands a transformation of the social order. But the government resists. It is still too powerful to invite a frontal attack. That is why there springs up a voluminous literature introducing new ideas under the cloak of utopias, travels, exoticism, orientalism, and desert islands. This literature condemns, attacks, and mocks the society and civilization of that period, the traditions, the contemporary manners, political and religious institutions. We must not be misled by the outward levity of these writings. For the violence which is at first concealed beneath the elegance, banter, and very affectation of the form soon rises to the surface, comes into full view, and becomes

acrimonious in proportion as the will of the public demands tangible results [1]

The eighteenth century represents in part a phase of individualism which sets man up as an entity distinct from social organization and will prepare the ground for pre-romanticism In the effort to reorganize society the individual is particularly interested in himself The better to analyze his elemental feelings he returns to a rational observation of the phenomena of life (Voltaire), he returns to nature (Rousseau) It follows, then, that all a priori views of the mind must submit to the test imposed by the natural and experimental sciences, by psychological and physiological studies As a result of that, literature becomes the vehicle of incessant attacks against all the systems upon which civilization was founded These systems stand condemned because, so the writers argue, they gave a false idea of life on earth, they drew erroneous conclusions concerning man's nature, they were unaware of or deliberately denied the evidence of facts by indulging in hypothetical speculations of the mind

In order to place man in his true environment, to know better his tendencies, a surer guidance now becomes necessary The psychological method strives to find the constituent elements of the human mind Using reason as its tool, this method seeks to eliminate from society all its ridiculousness, artificiality, and unwholesomeness Added to this wholly rational method, represented chiefly by Voltaire, is the so-called "naturist" method of Jean-Jacques Rousseau, who tries to recapture the image of primitive society founded solely upon the demands of nature Whatever be the differences that inhere in these two methods, they nevertheless postulate the same proposition, namely, that life must be governed by new rules, since the individual cannot find in contemporary civilization the happiness to which he is entitled

To understand fully man and his tendencies he must be studied in his contacts with nature, who is his mother, his nurse It is she that gives him life, it is to her that he returns after his death It is in her and in her constant, immutable laws that man with his limited vision and mind sees the reflection of the "divine clock-maker," the creator of all things We are all subjected to the inexorable necessity of God's laws, and if we would know man well we must observe na-

[1] In this connection see the *Barbier de Séville* by Beaumarchais and his more violent *Mariage de Figaro*, which followed nine years later

ture [2] That is why the natural and experimental sciences now assume such great importance in that they cooperate with reason, whose function is to draw conclusions from facts obtained through observation [3]

But Rousseau intervenes at this point According to him, science is not at all indispensable Reason, he holds, often deceives us in spite of its recognized usefulness For it is the fruit of reflection which is sometimes not unmixed with imagination, the source of so many errors The profound ignorance of primitive man deceives him very seldom, since his instincts and feelings, which spring directly from nature, compel him to obey its laws This view of Rousseau is shared by Abbé Prévost, Vauvenargues, Morelly, and Bernardin de Saint-Pierre

The partisans of reason and science proclaim, even as do the followers of Rousseau, the goodness of God and admit the goodness of nature Man, therefore, in spite of some possible defects and vices, is good, or generally tends to become better as soon as he begins to heed the dictates of natural laws Curé Meslier, La Mettrie, D'Holbach, Boindin, Rouelle, the recognized atheists of the time, and Duclos, Diderot, D'Alembert, Helvétius, Dulaurens, tinged a little by disbelief in God, believe in the goodness of nature and man, even while they are substituting for the rule of God the laws of a universal mechanism

The savage who is thought of as the embodiment of natural man now becomes the hero of novel and play, he becomes the preoccupation of a large part of French literature in the eighteenth century In him the writers study man's basic needs and primary feelings They seek to deduce from this study a code of morals, a conception of life which should lead to the reform of society

Certain thinkers, however, as, for example, Morelly and Rousseau, are afraid that the element of reflection in the savage, the intensification of his passions made possible by unforeseen obstacles may unfit him, temporarily at least, as an ideal subject for the immediate observation of nature's laws For this reason, in part, Condillac, Diderot, and Bonnet had already infused life into the *homme-statue* It

[2] The study of nature during the eighteenth century gives rise to a genre of descriptive poetry represented by Roucher, Saint-Lambert, and Abbé Delille

[3] This may be noticed throughout the writings of Fontenelle, Montesquieu, Voltaire Morelly, Diderot, D'Alembert, La Mettrie Helvétius D Holbach Buffon, le Père Buffier, Rouelle, Réaumur, the Encyclopedists, and the *Physiocrats*.

was preferable, however, it was more human and natural to observe in the child the dawn and progress of ideas, to behold the unfolding of his senses, *the development of his intelligence For in his case* the want of reason and reflection causes him to yield more readily than does the savage to the dictates of instinct and feeling Moreover, the psychology, physiology, and education of the child are more important than those of the adult He is the hope of the race, and upon him depends the civilization of the future Some sociologists, philosophers, doctors, and educators had already understood this But it is particularly the influence of Morelly and Rousseau that is responsible for the great interest in childhood shown by French literature during the second half of the eighteenth century

This study of man and child results in a series of well-defined observations Man is guided by the instinct of self-preservation, he tends to persevere in his being, and to accomplish this nature has inspired in him the fear of pain with its counterpart — the attraction of pleasure These two contrary reactions indicate that good and praiseworthy are the things which bring man pleasure, whereas everything that makes him suffer is bad, harmful, and deserving of condemnation By extension these two sentiments create the notion of vice and virtue, of what is just and unjust, propounding at the same time the principle of social utility These two sentiments also give rise to the theory of self-interest imposed upon man by nature, an interest which determines all of man's actions in both the physical and moral worlds and urges him on in the pursuit of happiness The *flight from pain, the quest of happiness* which eludes us even as we think it within our grasp, the need to follow the urge of the senses awaken in the individual the *tendency to activity* and bring into play all his passions From what precedes it is clear that most writers of the eighteenth century adhere to the doctrine of determinism and to the philosophy of sensationalism A notable exception is that of Rousseau who, nevertheless, recognizes the reasonableness of certain postulates of sensationalism [4]

The human passions are good, although they may become dangerous when they are given absolutely free rein and when the individual comes in contact with fellow men who, like himself, are governed by

[4] Vauvenargues and Voltaire in the beginning accept the doctrine of free-will considerably qualified, but later on they rally definitely to the cause of determinism.

their passions They are particularly bad as soon as man loses contact with nature, when they are thwarted and exacerbated by the artificial conventions of civilization But at this juncture the instinct of sociability, to which is added the inherent feeling of sympathy, benevolence, and compassion, serves to curb and guide the passions Rousseau notwithstanding — and his thought on this subject is far from being clear — man is made for society Everybody, individually and collectively, works towards a common goal, which is happiness, and the individual soon notices that he cannot find his own happiness except as he helps others to accomplish theirs In order to achieve solidarity and social utility, self-interest, which is first among the individual's rights, is now linked with the common interest of all [5]

Another of man's instincts, one of the most important, is the instinct of *émotivité*, which moves him to transmit life, to procreate, to continue his species by the attraction and union of the sexes Love, powerful motive force behind man's passions and actions, tends to achieve in this life, as completely as possible, human pleasure and happiness The sentiment of love is so strong that without it life is devoid of its greatest impelling force, and man falls into the completest ataraxy (ἀταραξία) That is why the writers of the eighteenth century indulged in descriptions of all phases of love,[6] and even of lust [7] This *émotivité* leads also to sensibility and its exaggerated expression in the writings of the time [8]

Then comes the acquisitive instinct, diversely discussed throughout the eighteenth century, from which derives the idea of property The possession of things in common does not satisfy man's nature He wants to own privately, and even writers of communistic tendencies, such as Morelly and Mably, accept what they call personal property But it is admitted on all sides that this sentiment must be closely watched, for it leads to avarice, the most dangerous of all vices

[5] Fontenelle, Abbé de Saint-Pierre, Vauvenargues Abbé Prévost Montesquieu Voltaire, Morelly, Diderot D Alembert Duclos Helvétius D Holbach, Abbé de Prades D Argens Buffon, Mably Raynal Turgot Saint-Lambert, Condorcet, the Encyclopedists, and the *Physiocrats*

[6] Mme de Graffigny Abbé Prévost, Rousseau, Diderot, Baculard d'Arnaud, Nivelle de la Chaussée Thomas, Mercier Restif de la Bretonne, Florian, Bernardin de Saint-Pierre and Léonard

[7] Voltaire, Crébillon fils Diderot Dulaurens, Restif de la Bretonne and, to some extent Montesquieu and Helvétius.

[8] By the writers listed in note 6

The tendencies of man, which are sometimes termed "natural laws" or "the laws of instinct," form together the rules of natural right, which is to give rise to the rights of man and of the citizen [9] The only thing that remains to be done now is to constitute a code of morals, which has often been discussed by Voltaire, Montesquieu, and Burlamaqui under the name of "*natural law*," "*law of reason and of justice*" The moment men decide to lead a communal life, a well-defined system of ethics becomes a preëminently social need What this ethic should be is indicated by the instincts, it derives from the sensations, and since its task is that of regulating the relationships first between men and then between nations it is formed, interpreted, and codified by human reason, by the combined intellectual effort of all Such an ethic must harmonize the individual's interest with the general interest, if it is to achieve the happiness of all, if it is to proclaim the brotherhood of men and guarantee the triumph of justice upon earth (religion of humanity) It is an essentially utilitarian, lay, and humanitarian ethic, and it leads directly to pacifism and internationalism Abbé de Saint-Pierre, Montesquieu, Voltaire, Morelly, La Mettrie, Diderot, Abbé de Prades, D'Alembert, D'Argens, Helvétius, D'Holbach, Duclos, Grimm, Raynal, Mably, Dulaurens, Marmontel, the Encyclopedists, and Condorcet sing the glory of this ethic and show what profit society can derive from it Rousseau himself, despite the profound divergence of his principles from those of other writers, gives his *Émile* an education solidly based upon the senses and upon a utilitarian code of morals.

Thanks to the development of the natural and experimental sciences, the study of secondary causes begins to assume great significance The relative importance of these causes is indicated by *mathematics, by geometry especially*, which Bossuet even in his own day called "the science of proportions and relationships" [10] The formulation of the new ethic is favored also by the physiological and psychological studies to which the individual is subjected, and all these new deductions show that the human race is capable of a greater development In order, then, to hasten the intellectual,

[9] Primarily in the works of Montesquieu, Voltaire, Rousseau, Raynal, Morelly, Mably, Morellet, and Condorcet

[10] It must be remembered, however, that Abbé Prévost, Montesquieu, Voltaire, Rousseau, and Bernardin de Saint-Pierre have always remained believers in a first cause.

moral, and material progress of man, hindered until then by the civilization of the *ancien régime*, man needs only take reason as his guide This is the theory of progress which offers a new conception of life Among those who best express in their work the belief in progress are Voltaire, the chief exponent of the doctrine of reason, Fontenelle, Abbé Dubos, Buffon, Turgot, and Condorcet

But another system of morals, another conception of life impeded the progress of the new doctrines and sought to rob them of all freedom of expression These obstacles were none other than the ethic and conception of life imposed upon the people by the Catholic Church and sustained at that time by two great forces They were founded, to begin with, upon sentiment, faith, and revelation, which are at once the sincerest expression of human emotions and aspirations and the basis of a noble and lofty tradition Upon this tradition, furthermore, solidly rested the doctrine of absolutism and rule by divine right, the security of the privileged classes, who now gave temporal support to the Church, thus repaying their indebtedness to the spiritual force which had sustained them throughout the ages

The writers of the eighteenth century do not deny that the Christian code of morals had its origin, even as did their own, in the human instincts and nature, but they declare that the systems and hypotheses built up by the mind have transformed it and led it into error The imposition of myths, symbols, and arbitrary concepts which represent Christian morals paralyzes the intelligence, hinders the improvement of society, and ends in the abdication of reason in the presence of faith and tradition This sad, odd code of morals is composed of incomprehensible dogmas and mysteries, whereas the hypocrisy of the theologians, their ambition, and their greed for power make of them a class to be dreaded in that it is their own advantage that they seek in their effort to influence the acts of the rulers Thanks to the power they have over body and soul, the theologians give free rein to fanaticism and intolerance They it is who have stirred up civil and religious wars, instigated the Saint-Bartholomew massacre, set up the inquisition, connived at the murder of good kings, and it is they who, aided by the avarice of the Spanish conquerors, have enslaved the natives of the New World and brought destruction upon them [11]

[11] Such a trend is constantly met with in Fontenelle, Montesquieu, Voltaire, Abbé Prévost, Mme de Graffigny, Morelly, D Argens, LaMettrie, Diderot,

According to the writers of the eighteenth century, the Christian conception of life is a solution, without proof, of the problem of destiny *Any conception which arrives at conclusions different from* its own is accused of being heretical and is punished as such by the temporal power Because of this the Church becomes the greatest obstacle to intellectual progress In making of heaven the seat of the true life Christianity preaches a sterile resignation to social iniquities, to the evils endured by humanity — iniquities and evils of which humanity could rid herself by the aid of work, science, and intelligence This doctrine makes of the earth a valley of tears and of despair, and the nation is shackled by a state of mind which thwarts all material progress The dogmas of original sin, of grace and free will, to which is linked the prescience of God, cannot be understood or accepted by human justice [12] Since the sin of our first parents has irretrievably corrupted and circumscribed man's nature, it follows that moral perfection is, according to the Church, only a vain hope, an unrealizable progress on earth

Fontenelle, Montesquieu, Voltaire, Diderot, D'Alembert, La Mettrie, D'Argens, Helvetius, D'Holbach, Curé Meslier, Morelly, Dulaurens, Raynal, the Encyclopedists, Naigeon, Fréret, and Condorcet, to name only the most violent writers, rebel against the Christian dogmas and ethic, they reject the decrees of the theologians' God *Écraser l'infâme* becomes the war cry against theology It is attacked on all sides and is made responsible for political errors and human suffering

Nevertheless, there is a God, the intelligent architect of the universe, the father of nature and human beings to whom he gave laws revealed by means of instinct, reason, sentiment, and conscience [13] This Supreme Being, who is good and just, rewards and punishes man according to his actions, either in heaven or upon earth [14] The human race, civilized and uncivilized, has always been aware of this rather pantheistic God and has worshiped him in all ages and coun-

D Alembert, the Encyclopedists Helvétius, D Holbach, Dulaurens, Raynal Mercier Marmontel, Mably, Grimm, and Condorcet

[12] Rousseau defends free will in all his works.

[13] Irreconcilable atheists or writers of atheistic tendencies such as Curé Meslier La Mettrie Rouelle, Diderot, D'Alembert, Helvétius, D Holbach, Dulaurens, Duclos, Boindin, and Grimm do not believe in conscience and remorse

[14] The writers of the eighteenth century, among the deists have never arrived at a definite conclusion concerning the after-life and the immortality of the soul

tries Such, in short, and very much simplified in expression, is the natural religion, or better still, the deism proclaimed in the works of Abbé de Saint-Pierre, Vauvenargues, Morelly, Montesquieu, Abbé Prévost, Voltaire, le Père Buffier, D'Argens, Rousseau, Buffon, Raynal, Marmontel, Florian, Mercier, Baculard d'Arnaud, Saint-Lambert, Thomas, Morellet, Delille, Condorcet, and others

Leaving aside the doubts and contradictions, neglecting the want of clarity and of sound conclusions, overlooking the continual hesitations of writers treating the same subject, we may ask by way of résumé, What is the activity of French thought in the eighteenth century? Fearing reprisals, contemporary thought most often expresses itself under the cloak of utopias, orientalism, exoticism, travels, and desert islands It wages violent war against the *ancien régime*, against everything that the old order represents political institutions, social conventions, manners, traditions, religious beliefs, all of which are held responsible for man's unhappiness But the *ancien régime* is the product of systems based upon a priori hypotheses of the mind These systems, linked with theology, have given rise to an ethic and a conception of life which hinder the intellectual, material, and moral progress of man It becomes, then, imperative to destroy theology, the spirit of system, and the arbitrary divinity which they proclaim

After all prejudices and errors have been attacked, destroyed, and swept clean, there must be discovered new directing principles capable of reforming and improving civilization To accomplish this, thought returns to the observation of nature, it gives itself over to the study of the experimental sciences and discovers the secondary causes in order to place man in the environment upon which he depends This much accomplished, thought now analyzes the basic needs of the individual It studies his instincts, the play of his passions as exemplified by the savage and the child

Thanks to all of these studies and to the aid of reason, thought reconstitutes what it considers a true human ethic and deduces from it a conception of life based upon the idea of progress Scorning revealed religions, it proclaims the existence of a God, father of all men

THE IMPLICATIONS OF PLOT IN LITERATURE

CHRISTIAN N WENGER

AN ADEQUATE study of any art phenomenon takes its point of departure in the postulate that rhythm is the monadic principle of all art products We assume as accepted, also, that literature is a manifestation of this monadic principle through *the word*, where the word, as the smallest autonomous unit of language, is made the symbol of all such units In accordance with these preliminary understandings we shall define plot in literature as the rhythmical representation of action through the word, that is, through language materials Such expansion and explication of this definition as seem requisite will appear as we proceed

In the study of plot literary criticism and aesthetics have been prolific in terminology, but unfortunately almost equally prodigal in the variety of connotations ascribed to many of their terms Over-inclusiveness in definition has led to confusions of plot with situation, story, fable, and kindred elements Overexclusiveness, on the contrary, has been the source of confusions between plot and pattern, model, outline, and other like diagrammatic features Throughout the many disparate critiques in the field one will find insistence upon the wildest of vagaries no less than upon the most parietal of dogmas The chief difficulty seems to be the lack of a consensual aesthetics One of the major objectives in this survey of plot implications is, therefore, to work toward a consensual terminology and a mutual understanding of terms

We have proposed that plot in literature be defined as the rhythmical representation of action through language materials The matter of prime importance in this is *action* The essential nature, source, attributes, correlations, and primary rhythms of this action will, therefore, be focal in our study And we may well begin by noting that this action has reference always chiefly to the incidents, episodes, or events wherein human beings are the objects in motion

Where supernatural beings, natural creatures other than man, or inanimate objects or forces are included they are given representation only because of their significant relevance to human happenings Focally, too, this action is that of individual human beings rather than that of groups Further, it is that selected action which appears to have pertinence for the critical situations or problems perennially faced by mankind These curt pronouncements will reappear duly qualified and liberalized as occasion invites

In addition to those noticed above, there are several other varieties of action which are excluded from literary plot Admissible action is, obviously, *represented action*, not action *per se* It is not a bare copy of actual happenings, for though mimesis [1] enters into the representational process, this process is something more than, and different from, mere phono-photographic copy work Again, we must exclude also from the represented action of literary art such activities as appear to be motivated merely or chiefly by survival and diversional values As we turn now to the task of characterizing in positive terms that action which is admissible and constitutes plot, those types here excluded and the grounds for their exclusion will, we trust, become sufficiently clarified

In attempting the positive task just mentioned we must first find a basic proposition upon which to proceed For such a proposition we refer to Dr Dahlstrom's introductory study to an aesthetics of literature [2] Therein we find the arts classified among those human activities whereby man attempts the enhancement of life Each part of any such activity will, presumably, be required to contribute toward the desired end The artist's selection of plot action must, then, lend its support to this attempt for enhancement values Since the general run of events in life are chiefly for survival or diversional ends, any representation of such events would give equal prominence to survival or diversional, rather than to enhancement, values Because the latter are his objectives, the literary artist must select for representation those actions which manifest the significance and worth of existence and which give those values above and beyond mere survival or diversion an illusion, at least, if not the promise, of permanence

[1] *The Poetics of Aristotle*, Edited with Critical Notes and a Translation by S H Butcher, I 7-11

[2] Dahlström, Carl E W I "An Introduction to the Critical Appreciation of Literature," pp 507-522 of this volume

Our access to those values, those timeless realities, to which we have just referred, is almost exclusively through the phenomenal activities of mankind Some such activities reflect those realities more than others Bound as he is to the representation of phenomenal action, then, the artist is obligated to select such unified sequences of events as best reveal the enhancement quests of humanity Here lies the heart of our problem If we can characterize those qualities which are given perceptibility, though shadowy it be, through the rhythmical disposal of selected phenomena, then we shall have resolved our difficulties It is evident that our task at this point is to describe intelligibly that shadowy reflection of human destiny rendered translucently visible through an X-raylike process of the artist which we have called rhythmical representation

I have here first named *destiny* that inherent reality which the artist presumes to make dominantly attentionable in his works This is to use the term in its Spenglerian sense [3] to signify the essential nature and purpose, embracing the autonomous route and goal, of the life, or unified sector of life, given representation The incidents, episodes, and events making up any such unified whole or part of life appear to be destined happenings, and the essential reality they make manifest is appropriately called a destiny The action here described is that which Aristotle characterizes as "probable and necessary" [4] It is that action which exhibits the "underlying order," the "wider realm of possibilities" in the life portrayed.[5] The essential realities thus presented have been variously designated by philosophers as "Ideas," "Noumena," and "Universals in the Particular" [6] Though these and similar terms are helpful toward an understanding of that essential nature of events which we wish to describe, the term "destiny" appears to be the most connotative single designation to that end [7] For it is, indeed, a veritable "manifest destiny" which we apprehend in the plot action of every effective artifact of literature

[3] Spengler, Oswald, *The Decline of the West*, tr C F Atkinson See especially I (Chap IV) 117-160

[4] *The Poetics of Aristotle*, IX 35 (see note 1)

[5] Cohen, Morris, *Reason and Nature*, p 69

[6] Windelband, W , *A History of Philosophy*, tr J H Tufts Consult the Index for page references.

[7] On the significance of a name see Goethe's *Faust*, Part I II i 150-156, in the translation by W H Van Der Smissen, p 45 (see bibliographical data at the end of this paper)

We have defined the action admissible in plot, as any unified series of events which gives the demarcations of a human destiny, either in whole or in sufficient part to offer clue to the whole Having thus characterized the fundamental nature of plot action, we are faced next with the problem of variant plot phenomena in the different literary genres Since an adequate treatment of this subject is incompatible with the scope and purpose of the present paper, we shall direct our inquiry to those general features of plot phenomena which remain fairly constant in all the genres One tentative hypothesis, however, we may venture in passing — that the requirements of plot action have played a considerable part in the origination and development of the primary genres and a dominant rôle in the rise and subsequent modifications of the various subgenres With this we leave the subject, except for such consideration as the genres will demand in connection with a treatment of magnitude, one of the correlations of plot action we shall take note of hereafter

We turn now to an inquiry concerning the origin and control of those plot events whose essential function it is to reveal human destiny Too little attention by far has been given to the study of those forces or agencies which appear to institute, maintain, and govern the happenings which comprise plot In the nature and behavior of these forces are discoverable whatever fundamental *Weltanschauung*, whatever basic interpretation of life and its universe the author may reveal

For the Greeks the source and governance of human destinies rested primarily with Fate, a *causa sui* back of all phenomena, and secondarily with the gods, themselves the subjects of Fate as a prime cause With the ancient Oriental authors the alignment of controlling agencies was much the same, though with varying distribution of supreme and subordinate power The supernatural agency has continued to play a considerable rôle among the forces to which, explicitly or implicitly, are assigned the sovereignty over plot action The Faustian world to which we belong, however, has, from Renaissance times on, given the human actors themselves a large share in that sovereignty In addition to those mentioned there are also the agencies operating in the environing world, both the animate creatures and the inanimate forces of that world By a study of Euripides' *Hippolytus*, Kalidasa's *Shakuntala*, Dante's *Divine Com-*

edy, and Thomas Hardy's *Tess of the D'Urbervilles* one may readily make a survey of practically all such forces

Some general classification and terminology for the agencies here in question seem desirable Since the matter so much involves philosophical considerations we turn again to the philosophers for assistance In their logomachies the forces or agencies under investigation are designated "causes" Any such force which appears to be the original and final authority over all others, itself nowise ever subordinate, is known as a "prime cause" And as a prime cause of this sort is given variant rôles by the philosophers, according to their interpretations and appraisals of the universe and its life, so the artists, too, in accordance with their *Weltanschauungen*, give a wide variety of powers to these supernatural prime forces, whether in the guise of Fate, a supreme deity, a hierarchy of gods, or other supernatural agencies of infinite variety

When we turn from the supernatural to the natural realm we distinguish four types of agencies or causes which, in philosophical terminology still, we shall designate as (1) formal, (2) material, (3) contingent, and (4) efficient [8] The first of these, the formal causes, represent the authors in their creative rôles, whether it be explicitly or implicitly that they appear to set events in motion and to manage their course to the conceived ends The material causes are those operating under the law of inertia These are twofold first, the material stuffs, that is, the language materials, through which the action is represented, and, second, the material world environmentally influencing the plot events The contingent causes include all those agencies which issue in fortuitous, chance, and accidental events The most significant of the four, the efficient causes, are those which appear to lie within the action itself, or in the principal actors

Since the actors represented in plot are chiefly human and the destinies portrayed human destinies, the efficient causes appear as forces activating individuals from within Of such forces there are two varieties, determined and psychogenic Through some characters the destinies seem to work blindly to their consummations Whether teleologically or by determinism, their routes and goals seem veritably identified with their whole organic being, without any visible influence of the mind Type characters manifest this

[8] Windelband, W, *op cit*, p 141

sort of governance, and romantic adventurers, too, seem often under the spell of such blind inner controls In contrast to this sort of agencies stands the psychogenic variety, which is of mental origin and operates under mental influences Of this type there are four kinds, according to the participation of the will, namely (1) volition, (2) motive, (3) incentive, and (4) impulse To these a fifth, inducement, might be added, provided "inducement" is defined in subjective terms

We have come now to a consideration of plot action in its partial and relative aspects In this province we have the attributes and the correlations of plot action to investigate The rhythmical attributes of plot action — varying always, we must bear in mind, according to the characteristics of the destiny represented — are six two relevant chiefly to the whole, one to both the whole and the parts, and three to the parts mainly As a whole this action has focus, line, and tempo, its parts have tempo, also, and in addition the attributes of position, direction, and function

Varying in accordance with the nature of the destiny portrayed, the focus of action falls upon situation, character, setting, or theme Where it falls upon situation it may unfold from an initially solved situation, as in *Antigone,* embody an implicit situation, as in *Hamlet,* or lead up to an emergent situation, as in *Rosmersholm* Where the focus is upon character it will exhibit static, forming, or disintegrating character With the setting in focus a temporal, a spatial, and a social environment, in variant degrees of prominence, occupy the center of attention and appear, either actively or passively, to instigate, maintain, and govern the destined events The possible variations where theme is focal are practically the same as those where situation is predominant

The line of plot action is single where there is but one plot in a literary work, multiple where there are subplots in addition to the main one In either case there may be several more or less parallel and simultaneous currents of action The presence of multiple line and current are the occasion for the correlational phenomenon of harmony, as will be noted in its proper place hereafter

Tempo, whether in the action as a whole or in its parts, may be uniform, accelerated, retarded, or suspended [9] Position, as was

[9] Cf Patterson, W M, *The Rhythm of Prose,* especially p 61, on tempo in the smaller prose units.

previously indicated, is an attribute of parts of plot action only Under this attribute plot events may be antecedent, initial, medial, offside, terminal, or residual In direction, which pertains also to the individual incidents, events, or episodes of the action, we find the attribute which gives occasion for the amplitude, or oscillations, within plot Its four phases are straightforward, ascending, descending, and reversed

The variants of the attribute known as function recall at many points those of the other attributes In this we are reminded that all these rhythmical attributes are cooperatively active The variants of function are especially numerous According to the service they render in plot we readily distinguish inductional, complicative, climactic, solutional, catastrophic, transitional, and terminative events Others indicative of rare or minor functions are not infrequently encountered The seven major types just mentioned are specially involved in the correlations of sequence and proportion

In the survey of the attributes of plot action just completed we have noted in several instances how these attributes may become the occasions for one or another type of correlation The complementary rôles of attributes and correlations will become further apparent as we proceed now, in an account of the latter, to note the kinship of part to part and part to whole among plot events The designations descriptive of the various kinds of relationship under this head we shall call the "indices of correlation" These indices are the seven much- and long-abused servants of the rhetoricians, namely (1) unity, (2) coherence, (3) sequence (also known as order or arrangement), (4) harmony, (5) symmetry (or balance), (6) proportion, and (7) magnitude (or scope)

Though often reduced to woeful appearances by the abuse of the rhetoricians, these kinships are still essential features of those rhythmical representations of event sequences which constitute literary products Rightly understood, they deserve reinstatement to the dignity of indispensable servants of art To that task my necessarily brief account of them can be, at best, only a beginning We start, then, with unity, which is a membership relation such that the totality of parts has oneness, that is to say, constitutes a whole The qualities of oneness are such as the represented destiny itself dictates To withhold gaps and extensions, either of the temporal or spatial order, which are essentially a part of the destiny to

be represented, is to defeat the ends of art So, too, is the imposition of gaps and extensions not innate to the destiny Hence in the classical unities we observe how a consensual dogma of the critic would play Procrustes to the detriment of artistry, and at the opposite end of the scale, in a romantic anarchy, we note how a consensual chaos would play Pandora to a like inimical effect These requirements for the *where* and the *when* are equally imperative for the *what* of plot events The unity of action, like that of time and place, is under sovereignty only to the rhythms of life in the destiny which the artist portrays We need add only that because this destiny is a unique whole each part is under the inexorable necessity of manifesting its proportional share of just that uniqueness which makes the art product the one and only of its kind [10]

Coherence, in contrast to unity, is that index of correlation which has to do with the kinship of part to part In plot this signifies relation of event to event and focuses chiefly upon the points of linkage before and after any part of the action The requirement this puts upon any plot event is that it appear essentially conjoined to those about it Thus the combinational rather than the oneness, or wholeness, aspect is here in perspective Sequence also focuses upon the relation of part to part, but instead of the points of linkage, the embrace at end points, it is the nature and appropriateness of order, of arrangement, that is here the center of attention To have significance a represented destiny must manifest direction and this direction of its happenings, moving as if to the consummation of the destiny, is the governing factor in matters of sequence

In the correlation known as harmony our investigation turns upon vertical rather than horizontal relationships, between simultaneous rather than successive events Here special difficulties are met in literature, which can present the simultaneous only when the events are of different categories of experience, such, for example, as sensation, thought, image, emotion, and deed Yet, through the flexibility of rhythmical words, literature can represent *as if* simultaneous what it can present only in sequence The problem arises chiefly where there is multiple line or current, or both, that is, where subplots or several currents of action in a single plot occur

[10] Cf *The Poetics of Aristotle*, VIII 33-35 (see note 1), Saintsbury, George, *History of Criticism*, 3 vols. (4th ed , Blackwood & Sons, Edinburgh and London, 1922), I 33, and II 216, 256, 267

Under the requirements of harmony each corresponding point in two or more of these lines or currents must be in concord A succession of such concords would constitute counterpoint Touchstone's proposal to Audrey in *As You Like It* corresponds roughly with Orlando's to Rosalind A succession of such correspondences may be found in Aldous Huxley's *Point Counterpoint* [11]

But harmony is often to be encountered also where there is but a single stream of events In such a stream successive sets of events frequently appear which show some degree of resemblance in configuration The points of correspondence in such sets may, in a relative sense, be viewed as simultaneous Here once more, then, there is that effect of vertical concords, as if an earlier or later correspondence were for the nonce superimposed, and we delight in another manifestation of harmony In this, however, we encroach upon the province of symmetry, or balance, or, to speak more precisely, we observe in this that in certain of their manifestations harmony and symmetry are identical

Symmetry in plot action is that correlation whereby a correspondence, or similarity, is manifest between parts lying upon opposite sides of a central plane or axis Such a disposition of parts gives an effect of balance This effect may be observable in the whole or in any part of sufficient magnitude to include an axis with similar parts in either direction Where its demands result in parts of similar magnitude on either side of an axis there symmetry has become identifiable with proportion, which is the correlation having reference to the magnitude of parts within the whole The demands of proportion require dimensional relationships such as avoid all distortions except those indigenous to the destiny to be represented

The last of the indices of correlation, magnitude, has been the ground of frequent confusions and controversies Its focus is upon the length, or duration, of the whole plot action Aristotle's prescription for tragedy was "a length which can be easily embraced by the memory " [12] We venture still further repetition to insist that the destiny to be represented, and not the spectator's memory, is the determining agency in drama, as elsewhere We believe that the rhythms of the destinies which artists wished to represent had

[11] Cf Gummere, F B , *A Handbook of Poetics*, p 1, Tovey D F , Article "Harmony " *Ency Brit* , 14th ed Huxley, Aldous, *Point Counterpoint*, p 293

[12] *The Poetics of Aristotle*, VII 33 (see note 1)

much to do in the origination and development of the primary genres, and that the magnitudes of these destinies were the controlling agencies in the rise and modification of the subgenres [13] We know that different destinies manifest themselves in different magnitudes Some artists apprehend those of certain magnitudes more readily than they do others The representation accords with the apprehension The artist makes or chooses his genre to accommodate the representation Such specifications of magnitude as ' a length which can be easily embraced by the memory," and "what can be perused at a single sitting," [14] are a posteriori impositions of theory by men specially gifted for the apprehension of destinies such as are represented in the magnitudes they extol For other gifts other magnitudes

It seems appropriate to conclude our study with an attempt to distinguish the primary plot rhythms manifest in literary representations For this purpose some common basis of classification must be adopted and held to The failure to observe this elementary requirement is causal of the confusions and absurdities in Georges Polti's *The Thirty-six Dramatic Situations* [15] and similar abortive mongering in this province We have found such a basis for all our previous classifications in the human destinies to be represented What has been so serviceable a ground of division will, we are convinced, prove the most valid basis upon which to distinguish those primary categories which we now seek Upon such a basis we make our attempt the less reluctantly, too, however difficult the task, for we probe here deeper still toward the essential nature and characteristics of all plot action, and to distinguish the primary plot rhythms upon the accepted basis will be at once also to differentiate those primary enhancement values which man has perennially sought in literary art

Upon the basis of the human destinies represented there are, to the best of our discernment, these five primary plot rhythms (1) the sufferance of fate, (2) the adventurous quest, (3) the struggle with the environing world, (4) the inner conflict, and (5) the effort for mediational values These five will be found to admit any and all

[13] Cf *supra*, p 546

[14] Poe, E A, Review of Hawthorne's *Twice-Told Tales*, in Vol VI of *The Works of Edgar Allan Poe*

[15] Polti, Georges, *The Thirty-Six Dramatic Situations*, tr L Ray

events relevant to the representation of human destinies and to exclude any and all events wanting in that relevance Every destiny revealed in art will readily fall within one or several of these categories Some destinies, to be sure, will transcend any one category That of a Faust, a Hamlet, a Don Quixote, for example, will embrace to some degree all five of these basic rhythms of organic life Because of the fulness with which they represent man's aspirations and endeavors, the works in which destinies such as these are set forth have ever seemed the richest and most profound of literary monuments In contrast to instances of this sort are the many destinies that are limited to but a single phase of some one of our categories Works in the genres of least magnitude and those of other restrictions stand in this case Most lyrics nicely illustrate this limited sort of representation Because of the intensity with which they represent the single or partial aspirations and endeavors of mankind, the works of this character, too, have regularly received their due moiety of critical appreciation

Be the destiny represented in any literary work great or small, the enhancement value will still offer that precise enrichment and understanding which some lives, some moments in every life most require These and whatever other offerings there may be found in literary art are available largely through the representational rhythms of plot action

University of Michigan

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SOME EFFECTS OF EMOTIONAL DISTURBANCE UPON MOTOR REACTION

WENDELL VREELAND

TEACHERS have long been impressed by the variability which appears in the school work of their pupils on different days and at different times of the day "Blue Monday" has often been cited as a reason for ineffective effort The weather, too, has been blamed for failure Extreme disappointment or shock has frequently been thought to shatter control over accustomed processes, extreme excitement or elation, to stimulate unusual success

What teachers have observed subjectively with respect to general variability of performance has been clearly revealed by objective tests ever since the measurement movement reached the educational field The score which a pupil makes upon the first administration of a test is not necessarily the one he would make upon an early repetition of the test This fact has been recognized by the expert in the field of measurement whenever he has spoken of the "unreliability" of the individual score Yet teachers frequently have found it necessary to base decisions for action upon no more reliable evidence than a single measure If there should be any high degree of relation between observed variability in performance on tests and such external conditions as the weather or excessively stimulating situations, it would seem unfair to base any judgment of the effectiveness of learning or of teaching upon test scores which are uncorrected for the effects of such factors

Dr S A Courtis of the University of Michigan is to be credited, so far as the present writer knows and is concerned, with the initial suggestion that it might be possible to adjust the score of an individual pupil or of a group of pupils in terms of achievement upon a "pilot test" *Ideally a pilot test ought to* be usable alike with young and old It ought to be a test in which success or failure would depend very little on school training Finally, it ought to be a test whose score would be sensitive to changes in internal states

and surrounding conditions Such a test Dr Courtis felt might be developed from a motor-reaction test which he had partly perfected

With an experimental pilot test at hand to form the basis for measurement a study was begun in the Detroit Public Schools in the autumn of 1932 to investigate the possibility of "correcting" test scores for the effects of extraneous factors Four schools were selected, and permission was secured to carry on a long series of daily tests with the pupils in grade 5B[1] In the selection of these schools a number of conditions were imposed in order that the results of the study might be generalized with some degree of validity to the schools of the entire city The median intelligence level of the pupils in each school was to be close to the average for the school system as a whole The schools were to be located in communities where socio-economic status was approximately equivalent and typical of the average socio-economic status for the city as a whole So far as possible, nationality, home language, and general type of student were to be the same in all schools The ones which were finally chosen as meeting these requirements were the Coolidge, the Marshall, the Wayne, and the Keating elementary schools

The first tests were given on October 31, 1932 The teachers in the four schools then repeated the tests on each school day thereafter up to and including December 23, 1932, the day on which Detroit schools closed for Christmas vacation In all, thirty-eight regular tests[2] were administered One hundred and forty-eight pupils participated in the experiment However, only a fraction of this number had perfect attendance records for the two-month period covered by the program of testing The present report is based upon the test scores of the sixty-five pupils who had not more than two absences in the series of thirty-eight regular tests

Before the administration of the series of tests had proceeded very far it seemed evident that factors were operative which were producing unusual results, now in one school, now in another For

[1] The writer wishes to acknowledge the kindness of the principals, Mr George A Birkam, Mr Theron A Gladden, Miss Florence Kuhn, and Mrs. Amelia D Young, for permission to work in their schools, and to express appreciation for the coöperation given him by the teachers, Miss Ida Solomon, Miss Mary Baker, Miss Etta Crozier, and Mrs. Edith M Haskins

[2] In the latter part of the experiment the teachers were asked to administer extra or "special" tests whenever in their opinion unusual conditions obtained in their classrooms. Thus the total number of tests which were taken by the several classes varied from forty to forty-four

instance, on a day when parents were invited to visit one of the schools all day, and to come and attend classes throughout the building, the average score of the fifth-grade pupils who were taking the regular test as a part of this experiment was found to advance over the previous day's score by what seemed an abnormally large amount On another day a principal of one of the schools talked to the pupils for a few moments before they took the test, urging them to make an exceptional record for their school, with the result that the class score for that group rose abruptly to a height it could not reach again for several days These increases, and others like them, were not paralleled on their particular days in the other schools Just before Thanksgiving vacation, however, it was noted that the scores of all groups showed a tendency to rise unusually, and after vacation to fall to levels which had characterized the learning curves of the groups some time before

These experiences seemed to indicate that emotional disturbances were producing upon the pilot test changes in score which were possibly more dominant than any other type of fluctuating cause If the variations were actually related to these emotional states and not merely the result of chance, it ought to be possible to produce similar disturbances in all four schools at the same time and make their curves move up or down together This suggestion led to a supplementary experiment which is the one reported in detail here[3] The purpose of this minor study was to discover whether like changes in environmental conditions, changes which would be designed to provoke like emotional states in pupils, would produce characteristic and consistent fluctuations in score upon the pilot test

In the main, the outline of this supplementary experiment was to be as follows About the middle of December each teacher, in coöperation with her pupils, would begin to lay plans for a party which would be held on the last school day before Christmas These plans might be as elaborate as the teacher and pupils wished Everything possible was to be done to build up a happy anticipation of the event On the morning of Friday, December 23, the day of the proposed Christmas party, the pilot test would be given at the accus-

[3] The writer is indebted to Dr S A Courtis for the general suggestion for this minor study, as he is for the major experiment as well Details in the administration of the research and in the analysis of the results are the responsibility of the writer

tomed time Soon thereafter, however, notice would come from the school office that it would be impossible for the pupils to go through with their plans for a party This was to be arranged in such a manner that the teacher as well as the pupils would be surprised and sorely disappointed After a little time, or whenever it became apparent to the pupils that the cancellation of the party was real, a second test would be administered Later on, lest the disappointment prove too serious, the pupils were to receive word that their party might go on as planned and they were to be let in on the secret that the whole affair had been a "frame-up" with a view to finding its effect upon their test scores

From the reports which teachers submitted in writing one may form an estimate of the success with which the conditions of the experiment produced the predicted disappointment The teacher in one school wrote

> After the children took the regular test they were notified they could not have the party They were very disappointed and depressed They had no desire to work since they had planned on having the party

Another teacher said

> The children surely were disappointed and *angry* They said their mothers had made the cookies. I made it worse by telling them they would get out at the regular time — not early, as they had been told

A third teacher wrote

> The children had a program planned and had worked on it for the past week Besides this, games and prizes were brought for entertainment Santa was to make his yearly visit and bring candy When the children were told they would have none of this, the disappointment was beyond description

The teacher of the fourth group reported that after the principal left, who had announced that there would be no Christmas party, since it was against the rule,

> the children were silent Then some began to ask questions about what we would do about the gifts and lunch They became spiteful One or two laughed hysterically Some refused to work Again, they were silent and frowned and pouted

The degree to which the introduction of disappointment with respect to the Christmas party affected scores upon the pilot test will be understood most clearly if the precise nature of the test, the method of scoring, and the type of analysis used have first been arrayed

The modification of Dr Courtis' test which was used throughout the experiment is called a "speed of movement test" (Fig 14) It consists of a series of five hundred circles and crosses arranged upon a single, unfolded sheet in groups of five, so that circles and crosses alternate both across the page and down The child taking the test is directed to place a cross upon each circle and a circle around each cross, beginning at the upper left-hand corner of the sheet and progressing from left to right across each line and down the page The

Name ______________________ Code No ____________

School ______________ Grade ______ Date ____________

(1) ______ (2) ______ (3) ______ (4) ______ (5) ______ Score

(1) ______ (2-1) ______ (3-2) ______ (4-3) ______ (5-4) ______ ______

Detroit Public Schools — SPEED OF MOVEMENT TEST Test 1 Form A (Circle and Cross) — Department of Research

0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x
x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0
0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x
x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0
0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x
x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0	x	0

Fig 14 Specimen section of "speed of movement test, test 1, form A

test as a whole consumes two and a half minutes The child is asked to indicate his progress at the end of each of the five half-minute intervals His score is the number of circles and crosses marked in *three half-minute intervals, his fastest and his slowest half-minute scores being discarded*

In spite of efforts to keep the pupils uniformly stimulated to make better and better scores upon the "circle-and-cross test," as they called it, it soon became evident that individuals' scores were fluctuating in irregular patterns from day to day This was as it had been hoped it would be But whereas it had been expected that

most pupils would approach a physical limit of speed upon the test at an early date and then vary above and below such an approximate maximum as conditions varied, it was soon observed that the test scores of individuals and of groups continued to rise In fact, these increasing scores seemed to be generating learning curves of fairly uniform nature Upon investigation it was found that the Gompertz curve, $y = kg^{c^x}$, represented in rather satisfactory manner the general

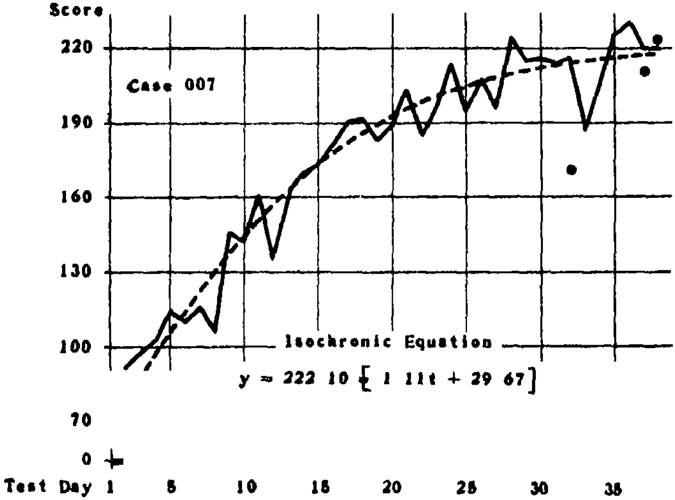

FIG 15 Illustration of a simplex Gompertz curve fitted to one pupil s scores upon the speed of movement test

trend for most of the pupils Consequently, the first step in the analysis of results of the major experiment was to fit a Gompertz curve to the scores made by each individual pupil [4] and to compute the difference between the score expected on each test day and the score which the child actually made These values were then referred to as "raw-difference" scores

[4] The method followed in fitting each Gompertz curve to the scores made by a pupil was that which is commonly referred to as the "method of averages." To facilitate the prediction of smoothed values for each successive day, the cumber some logarithmic equivalent of the exponential Gompertz equation was converted to its isochronic form

An illustration or two will make these steps clear In the vast majority of the cases the trend of the scores seemed adequately represented by what was called a "simplex" Gompertz curve, inasmuch as there was no marked tendency for the observed data to break into successive cycles or to reveal intermediate plateaus of learning The record of Case 007 is typical of the largest part of those studied (Fig 15) In a few cases, however, there were evidences that the learning curve was not simplex but "complex" Case 052 is an

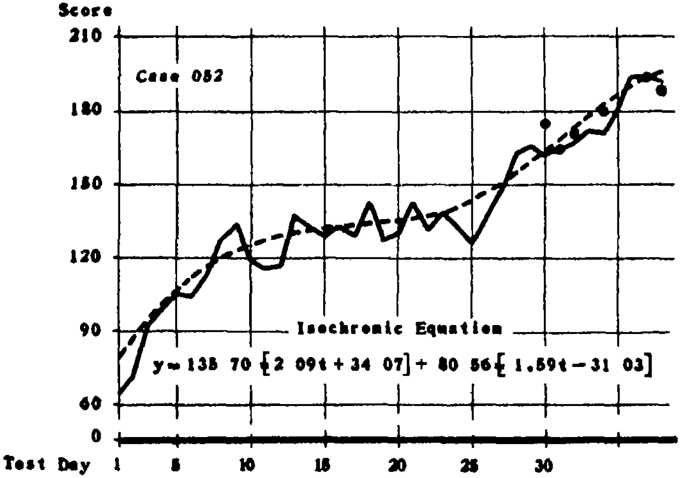

Fig 16 Illustration of a two-cycle "complex Gompertz curve fitted to one pupil s scores upon the speed of movement test

illustration of these (Fig 16) Whether the fitted curve was complex or simplex, the basic score of each child for each day was the signed difference between the score predicted by his curve and his actual test score

Inspection of many of these fitted curves revealed that for some pupils the deviations of the raw scores from the smoothed values were rather small The scores of other pupils, however, tended to fluctuate wildly In other words, there seemed to be evidence that individual pupils had individual patterns of variation about the learning curves established by the fitted equations Consequently

the raw-difference scores of each individual child were reduced to standard units by being divided by the standard error of his own raw-difference scores These values, which were thus corrected (1) for learning-curve trend and (2) for individual pattern of variation, were referred to as "standard-difference" scores

By its sign a standard-difference score reveals whether on the particular day the child's score is above or below his expected score, "plus" being above, "minus" being below By its size it reveals the general significance of the variation The larger the absolute value of the score, the more unusual a variation so great A standard-difference score may be expected to be larger than 1 00 in only approximately one third of the individual's scores Greater values may be interpreted similarly in terms of the curve of normal distribution Throughout the analysis of the results of the experiment all scores of individual pupils are expressed as standard-difference scores and may be subjected to this type of interpretation

The distribution of the pupils' standard-difference scores on the morning of Friday, December 23, before the disappointment with respect to the Christmas party, reveals that on the average their scores were fairly close to the scores predicted by their individual learning curves (Table I) In schools A and B the tendency was for the pupils to be somewhat above their predicted levels In schools C and D the tendency was for them to be below the expected mark If all groups are thrown together as one, the average standard-difference score is $+ 0\ 15\sigma$

After the disappointment (Table II) school A, which before had an average score of $+ 0\ 36\sigma$, made an average score of $- 0\ 05\sigma$, a net loss of $0\ 41\sigma$ In school B, however, the direction of the change was upward Whereas the score before the disappointment was $+ 0\ 37\sigma$, the average score afterwards was $+ 0\ 89\sigma$ A similar tendency was shown in school C, where the average score upon the first test was $- 0\ 05\sigma$ and upon the second test $+ 0\ 86\sigma$ In school D the reaction paralleled that in school A Here the initial score of $- 0\ 47\sigma$ was lowered to $- 0\ 85\sigma$ With all cases thrown together a general rise of score seems to have been produced Whereas the initial average score was $+ 0\ 15\sigma$, the final was $+ 0\ 41\sigma$, a gain of $0\ 26\sigma$

The question of the dependability of these results may well be raised Would successive repetitions of the experiment produce find-

TABLE I *

DISTRIBUTION OF STANDARD-DIFFERENCE SCORES BY SCHOOLS ON TEST PRECEDING DISAPPOINTMENT WITH RESPECT TO CHRISTMAS PARTY

Standard-difference score (Class mark)	School				Combined group
	A	B	C	D	
3.5	1	1			2
2.5		1	1		2
1.5	2	4	3		9
0.5	10	6	6	4	26
− 0.5	3	5	6	1	15
− 1.5	1	4		2	7
− 2.5	1		1	1	3
− 3.5					
− 4.5					
− 5.5					
− 6.5			1		1
Total	18	21	18	8	65
Mean	0.36	0.37	− 0.05	− 0.47	0.15
σ	1.19	1.32	1.81	1.24	1.43

TABLE II

DISTRIBUTION OF STANDARD-DIFFERENCE SCORES BY SCHOOLS ON TEST FOLLOWING DISAPPOINTMENT WITH RESPECT TO CHRISTMAS PARTY

Standard-difference score (Class mark)	School				Combined group
	A	B	C	D	
3.5		1	3		4
2.5	1	7	3		11
1.5	5	3	1		9
0.5	3	5	6	2	16
− 0.5	3	2	2	3	10
− 1.5	4	1	2	2	9
− 2.5	1		1	1	3
− 3.5	1	1			2
− 4.5		1			1
Total	18	21	18	8	65
Mean	− 0.05	0.89	0.86	− 0.85	0.41
σ	1.52	2.22	1.92	1.23	1.86

* In this table, as well as in Tables II and V, the reported means and standard deviations were computed from the original, itemized data and not from the frequency distributions which are presented here

TABLE III

SIGNIFICANCE OF OBSERVED MEAN GAINS

School	Mean gain	Gain / σ_{diff}	Interpretation
A	− 0.41	0.90	Not reliable
B	+ 0.52	0.92	Not reliable
C	+ 0.91	1.46	Possibly reliable
D	− 0.38	0.61	Not reliable
Combined group	+ 0.26	0.89	Not reliable

ings of the same sort? Of course, the fact that the direction of the changes in average score was positive in two schools and negative in two throws doubt on the generalization that a rise of score may be expected to accompany such disappointment as occurred here. Investigation of the statistical reliability of these gains throws further doubt on the tenability of any such conclusions. If each gain in mean score be divided by the standard error of the gain, the interpretation is compelled that in no case was the difference between

TABLE IV

DISTRIBUTION OF INDIVIDUAL PUPILS' STANDARD-DIFFERENCE SCORES BEFORE AND AFTER DISAPPOINTMENT WITH RESPECT TO CHRISTMAS PARTY

Score before disappointment	Score after disappointment									Total
	− 4.5	− 3.5	− 2.5	− 1.5	− 0.5	0.5	1.5	2.5	3.5	
3.5				1				1		2
2.5								1	1	2
1.5		1	2			3	1	1	1	9
0.5	1		2	2	4	7	4	4	2	26
− 0.5		1	2	3	3	4	1	1		15
− 1.5				1	3	1	2			7
− 2.5				2	1					3
− 3.5										
− 4.5										
− 5.5										
− 6.5				1						1
Total	1	2	6	10	11	15	8	8	4	65

TABLE V

DISTRIBUTION OF INDIVIDUAL PUPILS GAINS IN STANDARD-DIFFERENCE SCORES BETWEEN THE FIRST AND SECOND TESTS

Gain in standard-difference score (Class mark)	School				Combined group
	A	B	C	D	
4 5			1		1
3 5		1			1
2 5	1	2	2		5
1 5	3	7	7	1	18
0 5	5	6	2	4	17
− 0 5	3	2	3	1	9
− 1 5	3	1	3	1	8
− 2 5	1	1			2
− 3 5				1	1
− 4 5	2				2
− 5 5		1			1
Total	18	21	18	8	65
Mean	− 0 41	+ 0 52	+ 0 91	− 0 38	+ 0 26

the initial and final average score large enough so that it might not very properly be attributed to chance variation (Table III) Group measures, in other words, produced no conclusive evidence that the introduction of the experimental factor, disappointment with respect to a Christmas party, had any appreciable effect upon score on the pilot test

If we turn to a study of individual cases, however, we shall find another sort of picture Let the change of a score made by the individual child be computed as a "gain", the distribution of such gains then reveals the fact that these average changes are the result of widely varying individual reactions (Tables IV–V) Some children made final scores which were higher than their initial scores by as much as three and four sigma Three made final scores which were lower than their initial scores by four, five, and six sigma In fact, for only twenty-six pupils, or 40 per cent of the group, did the individual gain stay within the limits $\pm 1\sigma$ Thus, although the *general* tendency seems to have been for a slight and undependable increase in score, *individual* reactions appear to have varied from decided decreases in score to rather considerable increases In other

words, although the experimental factor produced only minor effects upon the average score of the group as a whole, it unquestionably produced marked effects on individuals in the group

One is led to wonder who the pupils are who make these greater changes in score Are they the pupils who, even after some forty trials on the test, have yet to reach the levels of their own maximum achievement upon the test? Or are they the pupils whose reactions throughout the major experiment mark them as variable? Correlations between pupils' gains and the maxima which are defined by the Gompertz curves fitted to the individual records reveal practically no relationship The Pearsonian coefficient of correlation is 0 046 The correlation between gain and the standard error of the pupils' raw-difference scores gives some slight basis for the generalization that wide change during this final phase of the experiment occurred most commonly among those who had revealed more than average variability in the total series of measurements In this case the coefficient of correlation is 0 373 — a relationship too loose, however, to impart much support to the suggestion that those who reacted most to the Christmas party disappointment were those who generally were most unstable as measured by the test

In the end, then, the contribution of this experiment gives further emphasis to individual differences It is probably questionable whether sharing with other members of a class the same bitter, disappointing experience produces in all the same emotional reaction Admittedly in this experiment no guarantee can be given that the same "emotion," whatever that may mean, was experienced by every child In fact, it may be that it is impossible to produce like emotions in the mass Certainly the evidence here is that individual variations, due presumably to the experimental factor, were markedly positive or negative in a large proportion of the cases Thus, whereas it may be impossible to predict much change in score for groups of pupils as a result of such disappointment as that which was introduced in this experiment, it would appear fairly certain that individuals would be affected in large degree even though the direction of the change in their scores is unpredictable on any basis as yet developed

Department of Research
Detroit Public Schools
Detroit, Michigan

DEER POPULATION IN MICHIGAN

ILO H BARTLETT

THE development of large-scale game management has been materially retarded by the lack of dependable census methods The need for accurate measurements of game population has been widely discussed, but relatively little effort has been expended in developing means whereby estimates may be obtained

The first attempt in Michigan to obtain a deer-census was made in the winter deeryards in 1928 [1] Relative population in adjacent areas was estimated through counts of deer beds within a definite period of time after a snowfall This method left many "loopholes" and did not give actual population

In 1930 Mr V H Cahalane was employed by the Michigan Department of Conservation, and after six months' field work made a map [2] of estimated deer population in the Lower Peninsula The figures, which ranged from one deer for every four square miles to thirty per square mile, were determined through track counts, abundance of other signs, "shining," and consultations with interested persons They gave a total of 35,000 deer in the Lower Peninsula, or about 3 9 deer per square mile of deer territory

In 1931 Bartlett and Wakeman of the Game Division carried on a similar investigation in the Upper Peninsula Nearly all previous methods used in obtaining census figures were found unreliable and were discarded New methods were necessarily devised A control plot was established This plot was worked intensively, and an estimate made of deer population per square mile With this figure as a base adjacent areas were investigated, and estimates were made which were comparisons with the first figure In this manner work progressed across the Upper Peninsula, and the population in

[1] Bartlett, Ilo H, and Stephenson, Joseph H, 'A Preliminary Survey of Deeryards in the Upper Peninsula of Michigan,' *Pap Mich Acad Sci Arts and Letters*, 10 (1928) 411–416, 1929

[2] This map is too complicated to be reproduced in print and therefore does not accompany this article

each new area was compared with the one adjacent on which the estimates had just been made In all cases the local conservation officers assisted, and their opinions were taken as the most accurate indication of deer abundance The actual figures for deer per square mile were not made final until all the data had been compiled on the maps and the various errors due to the "personal equation" of the large number of observers 'ironed out' as much as possible The resulting map [3] gives the estimated number of deer per square mile in the various localities In general, the population area boundaries follow timber type or timber density boundaries, but this does not always hold true In many instances overlapping occurred for no apparent reason The estimated population varied from one deer for each two square miles to twelve per square mile The total estimated number of deer in the Upper Peninsula, figured by these methods, was about 82,200, or an average of five per square mile

As a check on the method conservation officers have reported, over certain periods, all identified bucks, does, and fawns, as well as unidentified deer seen Also deer hunters were requested to report on special cards similar information for all deer seen during the hunt These figures were compiled and are valuable in themselves, but it was found impossible to correlate the three types of information At best they are only indicators of population and not actual population figures

The nearest approach to definite population figures came from Drummond Island, Chippewa County For the past three years the average number of bucks killed on the Island each season has been 390 The Island has an area of 130 square miles, therefore the average kill is three bucks per square mile Now if three bucks were shot, how many escaped? What was the percentage of kill? What percentage of the living bucks on the Island on November 14 was killed before the close of the sixteen-day season?

During the work on deer trapping and tagging in Alpena County in 1931, 49 bucks were tagged and released The following fall 7, or 14 3 per cent, of these tagged bucks were killed and reported These returns, although small, seem to be affected by the least number of variables

Fifty-three deer hunters' report cards were received from men

[3] This map is too complicated to be reproduced in an engraving and therefore does not accompany this article

who hunted on Drummond Island during the 1932 deer season These 53 men saw a total of 1,338 deer, or 168 bucks and 1,170 other deer This is an average of about one buck to each seven other deer seen Seventy-seven such cards were received from Drummond Island hunters after the 1931 deer season The ratio of bucks to other deer seen was one to five An average for the two years gives a ratio of one to six, i e one of each seven deer was a buck

Using 14 3 per cent, or one seventh, as the part of the buck herd killed, we obtain the following results If three bucks were killed on each square mile, this would be one seventh of the total number of bucks living on each square mile before the season Then the total would be 21 bucks per square mile Further, if there are 21 bucks per square mile and 6 other deer are seen for every buck identified, then there are six times 21, or 126 deer other than bucks, or a total, including the 21 bucks, of 147 deer on each square mile on the Island Such a large population seems almost impossible under existing conditions, if there is an error in the computations it probably lies in the percentage or part of the buck population that is reported killed each year

As has been mentioned, the percentage of kill used in the computations was obtained through the returns from a relatively small number of tagged deer This is undoubtedly the weak link in the chain In attempting to check this it was found from the deer hunters' report cards that in 1931 2,063 hunters saw 5,038 bucks Of these, 1,103 bucks, or approximately 22 per cent, were killed In 1932, 1,715 hunters reported that 1,205, or about 23 per cent of the 5,485 bucks seen, were killed It is almost certain that bucks seen alive were reported by more than one hunter, which may account for the discrepancy in these figures Since there is no way to check this repetition, these figures were not used in this computation However, any repetition would tend to raise the percentage of kill and lower the number of deer per square mile, which would seem more in accord with field observations For example, if there was a 25 per cent kill, which is higher than indicated by the hunters' reports, there would be 84 deer per square mile, which still seems preposterous, a 50 per cent kill would indicate a total of 42 deer per square mile, or an average of one deer for every fifteen acres This is still more than three times the maximum estimated population for Drummond Island or for any other area in the Upper Peninsula

However, it is questionable whether the majority of those familiar with the subject will admit that over half of the buck population is killed every hunting season

The deer-population map shows an estimate for Drummond Island of twelve deer per square mile As work along this line progresses it appears that the estimates on the map are low and that the population as computed above seems high The question now is how to obtain more accurate data

One more check is available In Menominee County, near Hermansville, during the establishment of a large fox-rearing ranch, a six-foot chain link fence with an overhang was constructed around a 440-acre tract of land When the fence was completed it was found that there were 14 deer on the inside If this can be taken as an average for that territory, there was approximately one deer to each 31 acres, which is equal to about 20 deer per square mile And this is not considered good deer country On the map the estimated population for this area is six per square mile

Now that some of the errors and discrepancies have been pointed out, just what can be done about it? It will always be difficult to determine the number of deer killed per square mile on any areas except those isolated, such as Drummond Island Through the deer hunters' report cards and the conservation officers' daily deer tallies fairly accurate data are now available on sex ratios, doe-fawn ratios, and ratios of bucks to other deer, but the figure most needed just now is the percentage of bucks killed each fall

Returns from live-trapping and tagging, though far too meager to date, seem to be the best method by which to obtain reliable data on percentage of kill It seems advisable to continue this trapping and tagging work on as large a scale as practicable in order to obtain sufficient returns to make the results as reliable as those which are obtained through the conservation officers' tallies and the deer hunters' report cards

Even this information would not result in actual population figures, but would be much more reliable than field estimates or the computations made to date

Department of Conservation
Lansing, Michigan

THE DATE OF EGG-LAYING OF THE FOUR TOED SALAMANDER *HEMIDACTYLIUM SCUTATUM* (SCHLEGEL) IN SOUTHERN MICHIGAN *

FRANK N BLANCHARD

FOR a number of years the writer has kept records of the time of egg-laying of the four-toed salamander, *Hemidactylium scutatum* (Schlegel), in Washtenaw County, Michigan and the immediate vicinity Since these records show relatively little variation from year to year, it seems desirable to publish the information now at hand The following account takes up the data year by year, and presents the facts on which the conclusions are based

1923

Whiteoak — On April 21, 1923, fifty-nine adult females were collected, mostly from sites suitable for egg-laying, in Whiteoak Township, Ingham County No eggs were found on this date The greater number of these females were dissected, and all but one had the eggs still in the ovaries, in the one exception they were in the lower end of the oviducts Of a number of individuals from this collection that were kept alive, many laid eggs that night and the next day (April 22) Therefore, April 22 and the night of April 21 may be taken as the dates of first deposition of eggs in 1923 at this locality

Pittsfield — At a place in Pittsfield Township, Washtenaw County, on April 29 of the same year (1923), a large number of eggs contained gastrulas and other embryos varying in development from two to thirty-two cells Also, a female was collected that laid eggs the next day, April 30 Several females collected here on April 20 had not laid their eggs, or even reached the pond This record furnishes egg-laying dates for this locality from about April 26 to 30

* Contribution from the Zoölogical Laboratory of the University of Michigan.

TABLE I

DATES OF EGG-LAYING OF *HEMIDACTYLIUM SCUTATUM* IN THE VICINITY OF WASHTENAW COUNTY MICHIGAN

Township in southern Michigan	Year	Date of collection	Probable date of first laying	Estimated period of principal laying
		April	April	April
Whiteoak	1923	21	21	22
Freedom	1923	23	22	22–23
Norvell	1923	28	26	26–29
Pittsfield	1923	29	26	26–30
Hamburg	1924	18	19	after 19
Freedom	1924	26	after 26	after 26
Dexter	1924	27	26	26–28
Hamburg	1925	22	20	20–25
Iosco	1925	26	20	20 23
Whiteoak	1930	18	16	17–20
Iosco	1930	26	24	24 26
Iosco	1931	14	12	13–16
Iosco	1932	28	26	27–28

Norvell — At another locality in Washtenaw County (Norvell Township) there were found on April 28 three nests of eggs and two females on separate nests ready to lay eggs These eggs had attained a development of 2 cells in one lot, 8 to 64 in another, and gastrulas in the third On April 29 a nest was discovered here containing 16- to 32-celled embryos Since the gastrula stage may be attained in the laboratory on the second or third day after deposition of the eggs — Humphrey [1] says 90 hours — the dates for laying at this locality in 1923 were approximately April 26 to 29

Freedom — In Freedom Township, Washtenaw County, on April 19, 1923, five adult females were collected at a distance from the pond, but only one was in a suitable egg-laying site None had yet laid Four days later, April 23, ten adult females were taken from nesting sites here A few were guarding eggs, but more had not

[1] Humphrey, R R. "Ovulation in the Four toed Salamander, *Hemidactylium scutatum*, and the External Features of Cleavage and Gastrulation," *Biol Bull*, 54 307–323 1928.

yet laid One lot of eggs had developed to blastulas and one was fresh In the laboratory eggs will reach the blastula stage on the day after deposition Dates for the first egg-laying at this locality in 1923 are, therefore, April 22 and 23

In this season the widest variation in date of laying in four habitats is thus seen to be only five days A summary of these records, as well as those of the years following, is given in the accompanying table

1924

Freedom — In 1924 two females with unlaid eggs were taken on April 26 at Freedom, in the habitat last mentioned Between these two years there was thus a calendar variation of at least five days in the same habitat

Hamburg — On April 18, 1924, at a locality in Hamburg Township, Livingston County, twenty-nine females with unlaid eggs were collected but no nests of eggs or spent females were found Four of these females were on shore, at positions varying from close to the edge of the water to fifty or more feet away The other twenty-five were taken from nesting sites in the pond In all except two of these females the eggs were in the ovaries, in these two part of them were in the oviducts

Two days later twenty-nine more females were taken here, twenty-four of which were with unlaid eggs In four of these the eggs were partly or wholly in the oviducts Four had laid all their eggs, and another had shed all but one of her eggs Four clusters of eggs were found in 1- to 4-, 4- to 8-, 2- to 8-, and 16- to 32-celled stages From these facts we see that in 1924 egg-laying began here on April 19 and 20

Dexter — On April 27, 1924, at Dexter Township, Washtenaw County, four females were taken with eggs in the ovaries, three with eggs partly in the oviducts, and eight that had laid their eggs Eggs were collected from nests, but no record of their stages of development was kept It is safe, however, to say that eggs were being laid here from April 26 to 28

1925

Hamburg — In 1925, at the locality in Hamburg where the collection of April 18, 1924, was made, eggs in the blastula stage were found on April 22, and two females with unlaid eggs were taken

from suitable nesting sites One of these females deposited eggs in the laboratory on April 25 Approximate dates for egg-laying at this habitat in this year are, therefore, about April 20 to 25

Iosco — On April 26, 1925, thirty-two females were collected from nests in a locality in Iosco, Ingham County Eggs collected on this day and examined on the next proved to be mostly in the neural-groove stage of development, some, however, were gastrulas and some showed the demarcation of the head No females with unlaid eggs were found The time of egg-laying for this year and locality may, therefore, be estimated as approximately April 20 to 23

1930

Whiteoak — On April 18, 1930, a large collection of females (231) was made at Whiteoak, Ingham County About half of these were laying or had laid eggs They were mostly in early cleavage, although one bunch had advanced to the gastrula stage

Iosco — On April 26, 1930, a larger collection of females (276) was made at Iosco in Livingston County Most of the eggs were already laid Several bunches examined were in the gastrula stage, and one was in the blastula A few females were laying, and a few others had not yet laid One was found still at the edge of the water This indicates an egg-laying season somewhat more protracted than is shown by some of the earlier observations It is to be presumed that adults hibernating in cooler situations, as on north slopes, migrate to the water and deposit eggs later than those in situations warmed earlier by the spring sun. At any rate this would explain the difference between these two observations of the year 1930

1931

Iosco — On April 14, 1931, the swamp at Iosco was visited again Although large numbers of females were found in egg-laying sites, relatively few eggs had been deposited Samples of eggs taken from many clusters disclosed no stages later than the gastrula. Many were in the blastula stage, many in early cleavage, and some were still undivided

1932

Iosco — A visit to the locality in Iosco Township on April 28, 1932, showed large numbers of nests with eggs in early segmentation

stages and blastulas Most of the egg-laying must have taken place within 24 hours, and the beginning could not have been more than two days before

CONCLUSIONS

The time at which the first eggs of Hemidactylium may be expected is definitely the middle of April It is evident that the egg-laying is accomplished in a very brief period — the last half of April, the collections show no females with unlaid eggs after April 29 That a few belated individuals deposit eggs in May must be granted, for a set of eggs in the gastrula stage was found at Sylvan Township, Washtenaw County, on May 13, 1923 It is only natural that occasional individuals may be late in reaching the nesting grounds

Differences of as much as several days are to be expected in the dates for laying in different localities in the same region

As related to other spring events, it appears that Hemidactylium will be laying when the hepaticas are beginning to blossom and the spring peepers (*Hyla crucifer*) are beginning to chorus

UNIVERSITY OF MICHIGAN

ARANEAE FROM THE NORTHERN PENINSULA OF MICHIGAN

ARTHUR M CHICKERING

DURING the past two years about 175 species of spiders have been listed from Michigan (Chickering, 1932, 1933) All were collected from the Southern Peninsula, the majority were from Calhoun, Jackson, Washtenaw, and Cheboygan counties Additions to this list from southern Michigan will be made as soon as collections which have been accumulating during the past year can be worked over

From June 27 until August 6, 1932, I collected spiders in the vicinity of Marquette, Michigan From the collections made during this period, together with a small number collected in recent years and contributed by Dr John N Lowe, Northern State Teachers College, 123 species have been identified Among these, 43 species have not been listed heretofore and are, therefore, given here, together with the collecting records It was at first intended to include brief notes with each species, in accordance with the plan of the previous lists in the series, but the cost of publication has prevented this This list brings to about 220 the total number of spiders identified in Michigan during the present studies The number now compares favorably with the numbers recently listed from Nebraska (Worley and Pickwell, 1931, 221 species), Oklahoma (Banks, Newport, and Bird, 1932, 160 species), and Washington (Worley, 1932, 173 species), but it falls far short of the long lists made in New England and New York, where 553 species and varieties have been recorded (Crosby, 1928)

In an effort to extend our knowledge of their occurrence and distribution in the state further collection and arrangement of these animals will proceed as rapidly as possible But enough material seems to be available now to warrant the preparation of a series of papers dealing with the various families of spiders in Michigan I am hoping to begin this work within a year and eventually to treat as adequately as possible all the families that occur in the state.

If it is possible, keys for the identification of genera and species will be provided

SUB-ORDER ARACHNOMORPHAE

Amaurobiidae

Amaurobius borealis Emerton — Marquette, July, August, Grand Marais, July, 1932

Agelenidae

Cicurina brevis (Emerton) — Grand Marais, July, Marquette, July, Negaunee, August, 1932

Hahnia cinerea Emerton — Negaunee, August, 1932

Tegenaria domestica (Clerck) — Marquette, October, 1931

Lycosidae

Lycosa aspersa Hentz — Marquette, October, 1931

Lycosa nidifex (Marx) — Grand Marais, July, 1932

Pardosa distincta (Blackwall) — Walsh, June, 1932

Pardosa mackenziana (Keyserling) — Numerous localities in Marquette and Alger counties, June, July, 1932

Pardosa modica (Blackwall) — Ishpeming, May, 1931, Marquette, July, 1932

Dictynidae

In my previous lists of Michigan spiders three species of Dictyna have been recognized Among the large number taken in the Northern Peninsula three additional species seem to be present I have been unable to make a decision in regard to their identification, and hence I am listing them as follows

Dictyna sp (?)

Dictyna sp (?)

Dictyna sp (?)

Lathys foxii (Marx) — Marquette, July, August, 1932

Scotolathys pallida (Marx) — Marquette, July, 1932

Theridiidae

Asagena americana Emerton — Marquette, July, 1932

Theridion differens Emerton — Birch, July, 1932

Theridion montanum Emerton — Marquette, June, 1932

THERIDION SEXPUNCTATUM Emerton — Marquette, July, 1932
THERIDION SP (?)
THERIDION SP (?)
THERIDION SP (?)

LINYPHIIDAE

BATHYPHANTES NIGRINUS (Westring) — Marquette, July, 1932
GONATIUM RUBENS (Blackwall) — Marquette, August, 1932

ARGIOPIDAE

ARANEUS CUCURBITINUS Clerck — Marquette, Grand Marais, July, 1932

ZILLA MONTANA C Koch — Grand Marais, July, 1932

DRASSIDAE (GNAPHOSIDAE)

I am much indebted to Dr R V Chamberlin for the examination of my collection of Drassidae from the Northern Peninsula From his list of determinations the following should be added to those which I have already reported for the state

DRASSYLUS NIGER Banks — Big Bay, Marquette, July, 1932
GNAPHOSA PARVULA Banks — Big Bay, July, 1932
HAPLODRASSUS BICORNIS (Emerton) — Marquette, July, 1932
HAPLODRASSUS SIGNIFER (C Koch) — Marquette, June, July, 1932
ZELOTES PURITANUS Chamberlin — Marquette, July, 1932
ZELOTES SUBTERRANEUS (C Koch) — Marquette, July, 1932

THOMISIDAE

For the second consecutive year I have had the very generous coöperation of Mr W J Gertsch, of the American Museum of Natural History, in identifying my Thomisidae From among them the following should be added to those already reported

PHILODROMUS CANADENSIS Emerton — Marquette, Munising, July, 1932

PHILODROMUS PICTUS Emerton — Marquette, July, 1932
XYSTICUS TRIGUTTATUS Keyserling — Marquette, June, July, 1932

CLUBIONIDAE

AGROECA ORNATA Banks — Marquette, July, 1932
AGROECA PRATENSIS Emerton — Marquette, July, 1932

ATTIDAE

METAPHIDIPPUS CAPITATUS (Hentz) — Gladstone, August, Marquette, Negaunee, July, 1932

METAPHIDIPPUS FLAVIPEDES Peckham — Sands, Marquette, July, 1932

METAPHIDIPPUS SP (?)

PELLENES AGILIS (Banks)

PELLENES DECORUS (Blackwall)

PELLENES PEREGRINUS (Peckham)

PHIDIPPUS CARDINALIS (Hentz) — Ishpeming, June, 1931

ALBION COLLEGE
ALBION, MICHIGAN

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AGE, GROWTH, AND SEX RATIOS IN THE CRAYFISH, *FAXONIUS PROPINQUUS*

EDWIN P CREASER

THE writer [1] has recently employed a new method for the study of seasonal changes in male crayfish Data were also obtained at the same time for the present paper on age-groups, growth, and sex ratios of the common crayfish, *Faxonius propinquus*

METHOD

Specimens were collected at intervals of about six weeks throughout the year, these were measured in millimeters for length of cephalothorax All specimens were obtained by seining from the Huron River near Dexter, Michigan Two graphs have been plotted from this material, one, for seasonal changes in males, the other (Fig 17 of this paper) for growth and age-groups in both sexes The sexes have been plotted separately to ascertain whether or not sexual differences exist In the accompanying graph the ordinates give the number of individuals, the abscissae, the length of the cephalothorax in millimeters In this investigation 3,544 crayfish have been examined, and 3,495 of these have been measured

SIMILAR GROWTH OF SEXES

A comparison of the curves obtained for males and females reveals no sexual differences in length of cephalothorax The molting, apparently without growth in males, when a change occurs in type of sexual appendage, is a possible exception which is mentioned later The curves obtained for the two sexes are practically identical Measurements on one sex can be used for drawing conclusions regarding age-groups, and this is a virtue of the method, since females frequently outnumber the males

[1] Creaser, Edwin P, "Seasonal Changes in the Male Population of *Faxonius propinquus* (Girard)," *Occ Pap Mus Zool., Univ Mich*, No 253 1-9 1933, one graph

[2] *Ibid*, graph facing p 6

DETERMINATION OF YEAR-GROUPS

The plotted growth-frequency curves for each sex show that the great majority of crayfish are referable to two age-groups These divisions are considered age-groups for the following reasons (1) the groups are consistently maintained throughout the year, (2) the

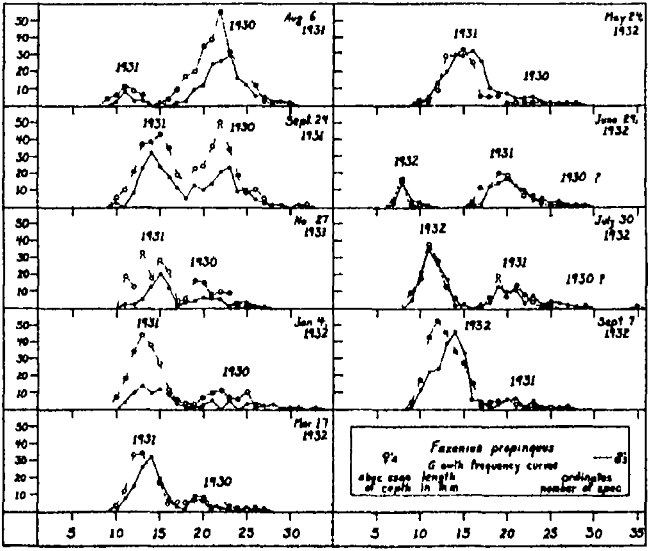

FIGURE 17

younger group reveals a strong growth increment (except in winter), (3) in one year the average size moves up to that shown by the older group one year previously, (4) in the second summer a new group appears to match the young of the year of the previous summer, (5) the older of the two groups gradually disappears

EARLY GROWTH, CESSATION AND RENEWAL OF GROWTH

The year-class, which first appear in June (the young of the year), continue to grow until September, but do not grow during

the period from September 24 to March or a little later They overwinter at a size of from about 10 to 20 mm, averaging nearly 15 mm in length of cephalothorax This cessation of growth may be due to temperature, since in this latitude crayfish do not feed in winter The older age-group, meanwhile, gradually decreases in numbers Between March 17 and June 29 the young of the previous year resume their growth, rapidly increasing to adult size, probably by reason of several moltings

RELATIVE ABUNDANCE OF INDIVIDUALS IN THE TWO YEAR-GROUPS

In the 1931 samples the young crayfish of the year greatly outnumbered the yearling when they became large enough to be thoroughly represented in the catch In the 1932 collections the yearling were relatively much fewer than in 1931 as compared with the number of the young of the year This circumstance may have resulted either from the depletion of the 1931 brood by intensive collecting or from a very successful hatch in the 1932 season Such large hatches are the supposed bases of the "dominant year-classes" of the fishery workers

AGE AT MATURITY

The breeding season of this crayfish occurs in the fall Fifteen specimens with eggs were obtained on May 24, 1932 The measurements of fourteen were as follows one each, 15, 16, 17, and 18 mm, five, 19 mm, and one each, 20, 21, 23, 24, and 25 mm Egg production seemingly occurs in both age-groups Among the yearling specimens there is apparently a greater percentage of ovigerous females than among the young of the year Similarly only a small proportion of the young males molt into the first form before the breeding season Presumably only a small percentage of females can mate as young of the year unless the males are polygamous, because observations indicate that mating pairs are of about the same size

MAXIMUM AGE

Approximately one year after hatching the young attain a maximum size of about 21 mm After this size is reached many live through most or all of the second year The numbers of this yearling group gradually diminish A few apparently pass over a second winter and become two years old The short life of *Faxonius pro-*

pinquus cannot be plausibly attributed to any human agency The elimination of older age-groups is a common feature of depletion by man of the stock of aquatic animals, but cannot apply to this small species of crayfish It is probable that man's intervention has operated to increase rather than to decrease the numbers of crayfish Their enemies have obviously been more seriously depleted than they themselves These enemies include the game fishes and such fur animals as mink, muskrat, and raccoon The depletion of the predators might also be advantageous to the crayfish by cutting out one host in the life-cycle of parasites affecting them, such as *Paragonimus* and *Crepidostomum*

MOLTING WITHOUT GROWTH (?)

Some evidence is available to show that growth does not always accompany molting The supposition that molting occurs without growth when the second form males change into the first form in autumn awaits experimental proof, but is indicated by the graph of my previous paper, which shows the seasonal changes in the form of male No growth is indicated on the graph for the females of a corresponding age-group at the period, from August 6 to September 24

SEX RATIOS

An entirely unsuspected result of these extensive collections pertains to the sex ratio This ratio undergoes a very unusual change during the year, as is shown in the accompanying table

TABLE I

SEX RATIOS

Date	Number of males	Number of females	Percentage of males	Percentage of females
Aug 6 1931	172	305	36	64
Sept 24 1931	238	459	34	66
Nov 27 1931	89	206	30	70
Jan 4, 1932	97	262	27	73
March 17 1932	146	164	47	53
May 24, 1932	200	151	57	43
June 29 1932	108	118	48	52
July 30, 1932	168	178	49	51
Sept 7, 1932	213	270	44	56

The graph (Fig 17) shows that this peculiar change in sex ratio cannot be attributed to any one year-group During this period both year-groups behave in a similar manner as regards sex ratios The factors causing these changeable ratios are not definitely known Apparently there is either a differential mortality in the winter or else the method of collecting does not obtain representative samples for sex ratios

SUMMARY

Several conclusions regarding growth, age-groups, and sex ratios in *Faxonius propinquus* have been reached in this study

1 Both sexes grow at approximately the same rate

2 Size-frequency graphs give an indication of age-groups

3 Growth during the first year is rapid

4 No growth occurs from September 24 to March or a little later

5 Growth is renewed in the spring, and adult size is attained by July

6 The relative abundance of a given age-group may vary from year to year

7 Ovigerous females occur in both age-groups, but probably in only a small percentage of the young of the year

8 Young crayfish attain a size of about 21 mm at the age of one year, and apparently few pass through a second winter

9 Man's influence has probably increased the numbers of crayfish by reducing the number of game fishes and fur animals that are their enemies

10 Molting without growth apparently occurs in the male

11 The sex ratio in this species is not constant, and this condition cannot be attributed to the influence of any particular age-group

Cranbrook Institute of Science
Bloomfield Hills, Michigan

STUDIES ON THE BREEDING HABITS AND YOUNG OF THE COPPERHEAD, *AGKISTRODON MOKASEN* BEAUVOIS *

HOWARD K GLOYD

THE scarcity of accurate information concerning many phases of the life-histories of American nearctic pit vipers has been made quite obvious by the recent development of interest in the biology of poisonous snakes In the late summer of 1925 observations on the birth of five broods of young copperheads in the laboratory induced the writer to continue studies on several features of the life-history of this species The work was carried on each season thereafter until the fall of 1929, when it was found necessary to discontinue it temporarily In the spring of 1931, however, the opportunity to make some additional observations was offered The results of these studies, which pertain to the breeding habits and young, are presented in this paper

The snakes on which the studies are based were collected in the following localities in eastern Kansas Gould's Ford, seven miles southeast of Ottawa, Franklin County, Fontana, Miami County, La Cygne, Linn County, Manhattan, Riley County, Irving, Marshall County, and Xenia, Bourbon County Larger numbers were taken in the spring and fall, but a few were secured during each of the summer months

The major part of the field observations was made in the region of Gould's Ford on Middle Creek, Franklin County, Kansas In this locality a wooded limestone bluff, with a southeastern exposure from thirty to eighty feet high, forms the north bank of the creek for slightly less than half a mile It slopes gently toward the creek at its upstream end, but rises abruptly with a very steep acclivity at its other extremity In addition to many deep crevices used by the

* Contribution from the Department of Zoölogy, Kansas State College, and the Zoölogical Laboratory of the University of Michigan

snakes for hibernating quarters loose slabs of rock scattered along the slope furnished satisfactory shelter during the summer months

The snakes kept for observation in the laboratory were supplied with water at all times and with food at frequent intervals A breeding colony of white mice was maintained to insure a dependable source of food, and English sparrows were sometimes obtained The laboratory cages were for the most part unexposed to sunlight In the spring of 1929, however, a number of cages were placed out of doors where some sunshine and shade were available almost the entire day, as shown by their greater readiness to take food and the regularity and facility with which they shed their skins, the snakes kept outside had much better general health than those indoors Gravid females were separated in glass-topped boxes 4 × 8 × 10 inches in size until after the birth of their young

From 1925 to 1927 this work was carried on in the Museum of Ottawa University, Ottawa, Kansas, from the fall of 1927 to the summer of 1929 in the Zoological Laboratory of the Kansas State College, Manhattan, Kansas, and from the fall of 1929 to date in the Zoölogical Laboratory of the University of Michigan The writer is grateful to Dr W B Wilson, of Ottawa University, and to Dr R K Nabours, of the Department of Zoölogy, Kansas State College, for many kindnesses in providing facilities for these investigations, to Dr George F Johnson, Department of Zoölogy, Kansas State College, and to Dr Frank N Blanchard, Department of Zoölogy, University of Michigan, for suggestions and criticisms, to Leonora K Gloyd for assistance with the microtechnique, and to several friends for help in obtaining specimens

BREEDING HABITS

Mating — In the course of these studies the act of mating was not witnessed in the copperhead, but field observations during the years 1926, 1927, and 1928 indicated that mating in the Kansas region normally occurs in April and early May During this five- or six-week period copperheads just emerging from their hibernating crevices were found in abundance at the Gould's Ford bluff described above Often several were discovered beneath the same rock The sex of such individuals was determined, and males and females were very frequently found together, but at that time no dissections were made to see whether mating had taken place

To determine whether or not the males were capable of producing or possessing spermatozoa in the genital tracts at all times during their active season the vasa deferentia of freshly killed specimens were examined at intervals during the years 1928 and 1929 The end of an excised vas deferens was gently pulled between a dissecting needle and a glass slide, and the seminal fluid so obtained was diluted with a drop or two of normal saline solution Microscopical examinations of such preparations made at intervals during the months of April, May, June, July, August, and October all showed the presence of more or less active spermatozoa

On account of the possibility of late seasonal mating a number of fall-caught females were dissected while fresh and examined microscopically for spermatozoa Two females were taken in company with males, each pair was discovered beneath a stone One collected on October 7 was examined the following day No spermatozoa were found in smears made from the mucous membranes of the vaginae and uteri [1] Another female, collected on October 30, had a large mass of viscous fluid in the posterior end of the right uterus and vagina Preparations made from this and from the contents of the uteri at intervals throughout their length were allowed to dry in air and were stained in Delafield's haematoxylin Many deeply staining bodies thought to be sloughed epithelial cells were visible, but no spermatozoa were found A similar examination revealed no spermatozoa in a smaller female which, however, appeared to be immature The genital tracts of four females collected after the middle of September, 1929, were examined microscopically on October 5 No spermatozoa or other evidences of mating were found

During the months of April and May, 1929 and 1931, sixty-nine female copperheads were examined Of this number eight were obviously immature, as shown by their small size and the relatively incomplete development of their gonads and genital tracts, and two others were probably immature The remaining fifty-nine, which were considered adults, were tested for spermatozoa by a microscopical examination of the contents of the genital tract either from a dissected snake or by means of a sample taken from the vaginae of

[1] Since in an ovoviviparous snake the terms 'uterus' and 'vagina' express more accurately the functional relationships of these parts of the genital tracts than the more commonly used word oviduct the writer follows the terminology of R. Wiedersheim, *Vergleichende Anatomie der Wirbeltiere* (Siebente Auflage, Jena, 1909)

living specimens by the following method By means of a sterile pipette a few drops of normal saline solution were injected into each vagina, the cloacal aperture of which could be seen when the anal opening was dilated The washings of the vaginal mucosa, then mixed with the saline solution, were drawn back into the pipette and placed upon a slide Both vaginae of each snake were examined in this way After each sample had been taken the pipettes were rinsed carefully and allowed to stand for several minutes in acidified 70 per cent alcohol, which was later removed by washing in distilled water The tests were considered "positive" if active spermatozoa were present, and "negative" if none were found

Of the fifty-nine sexually mature females examined twenty-one, or about 35 6 per cent, contained active spermatozoa in either one or both vaginae or uteri These females were examined within a few days of their capture, and most of them were separated from the males soon after they were received at the laboratory It is not probable that any matings took place after the snakes were collected, for they were observed frequently and, as is generally well known, the pit vipers rarely mate in captivity Though the possibility must be considered that the spermatozoa found may have been present as the result of copulation during the preceding fall, it seems improbable that they could have retained their evident vitality throughout the winter

As an indication of the possible length of life of the spermatozoa in the vaginae of the females, observations on three individuals are of interest Two of these were collected on April 12, found "sperm positive" four days later, and dissected on April 23 and May 9 Active spermatozoa were present in the first on April 23, but in the second, examined on May 9, only dead ones were found A third female, collected on April 7, contained active spermatozoa on April 18, but when it was dissected on April 30 all the sperm cells found were apparently dead If no copulation took place while the snakes were in transit, it would seem from these observations that the male germ cells may live within the body of the female eleven days and perhaps considerably longer

Although observations on the breeding habits of crotalid snakes in general are few, the majority of those on record for the nearctic species report copulation in April and May Only two published references to the time of mating of the copperhead under field con-

ditions have come to the attention of the writer In referring to this species Hay (1892 *a*, p 386) says "As to the time of the pairing of the sexes, I have knowledge of only one observation My friend, Rev A M Hall, brought me from western Pennsylvania two specimens of this species, which he took while pairing, on the 28th of August Unfortunately the female was disposed of before my investigation of this subject was begun "

Beyer (1898, pp 19–20) records his observations in southern Louisiana as follows "On April 12, 1895, a negro came to me with two magnificent copperheads, which he said he had caught the previous evening in a canebrake in the act of copulation I did not notice anything until late in the evening of September 16, when the female brought forth seven young I have certainly no reason to doubt the negro's statement, especially as a later dissection proved the other snake to have been a male "

In the absence of any confirmative evidence Hay's record of late seasonal mating in the copperhead may be considered open to question, especially since it is not a first-hand observation Although insufficient fall material has been examined to prove that copulation does not occur at times other than during the spring months, the fact that of the adult females taken in the spring over 35 per cent of them had mated a short time previous to their capture, as indicated by the presence of vigorously active spermatozoa in their genital tracts, may safely be regarded as positive evidence, if not complete proof, of spring mating The presence of active spermatozoa in the males throughout the season when out of hibernation probably has little significance in this connection

From the evidence at hand it seems reasonable to conclude that mating in the copperhead occurs during April and the early part of May, when the snakes are just emerging from hibernation and may be present in considerable numbers in one location, not yet having scattered over surrounding territory, as they have done later in the summer The actual breeding season is probably shorter and doubtless varies from year to year, depending upon weather conditions

Gravid females — Gravid females were collected during the middle and latter part of the summer of each year from 1925 to 1929 With the exception of two or three which were on rocky ledges and one which was on top of a bluff in the green grass of a pasture, all were found beneath large, flat stones or in some sheltering crevice

One particular rocky crevice, in which gravid females were collected during three successive seasons, was for some reason especially attractive to the snakes It was in an open space on the top of the high end of the Gould's Ford bluff, under the southeastern edge of a large, immovable fragment of limestone The cavity was a pocket-like recess extending back about ten or twelve inches, with the opening about two inches high

No males accompanying females were found during July or August, but on three occasions two or three gravid females were discovered in the same location In 1927 two were in the crevice described, in 1928 there were three, in 1927 two others were sheltered by a flat stone four feet across This gregarious tendency in gravid female copperheads was noted by J A Allen (1868), who recorded some observations of a Mr C W Bennett in Massachusetts Because this account is of considerable interest a part of it (p 179) may be quoted here "Of five specimens killed July 4th (several years since), all were females, but no embryos were observed in them *They were all found in a heap* At another time, later in July, seven were killed, which, like the others, were all found lying within the space of a square yard and were all females Five of them were examined by Mr Bennett, and found to contain slightly developed embryos In September, probably early in the month (the exact date was not noted), six specimens, all females, and all found in a heap, were killed, each of which had either seven or nine young"

From the information at present available the significance of this tendency of gravid females to congregate in a small area is not apparent In the cases observed by the writer it may perhaps be explainable as a response to an instinct to find a suitable shelter in which to spend the critical period of parturition, and it is not surprising that several individuals should sometimes be attracted to the same spot However, since Dr Allen does not describe the habitats in which Mr Bennett's observations were made, it cannot be assumed that the conditions observed by him were essentially similar Further observations on this habit are much to be desired

The eggs developing in the uteri of the females caught late in the season were usually quite evident when the snakes were handled In those under observation during the early summer the eggs were of sufficient size to be noticeable about the middle of June When a

snake was held by the neck, tail downward, a definite increase in the size of the posterior third of its body was easily seen, and even when it was on the ground in the normal position the enlargement of the abdominal region was evident The eggs could be felt and even counted by drawing the snake's body through the hand, with the thumb against the ventral side

Process of parturition — During the six seasons in which these studies were made twenty captive females gave birth to young in the late summer or early fall Parturition took place at night in every case except one Although on several occasions the young were discovered within a few hours after birth, sometimes while the moist prenatal membranes were still inclosing them, the act of parturition was observed in only two females

The first of these had already brought forth two young snakes, one of which was moving about and the other lying quietly within the membranes when discovered at 1 00 P M A third was extruded at 1 17 and a fourth at 2 00 Each of the three young snakes observed remained quiet about forty-five minutes after birth Then they twisted their heads slightly, ruptured the inclosing membranes by extending their necks, and began to explore their surroundings In one case the prenatal yolk had not been entirely taken into the body (Pl LXXVII, Fig 1)

More details of the process were observed in the case of the second female, which was noticed about 9 30 P M moving restlessly about the box and nervously twitching the posterior part of her body The tail was elevated to an angle of about forty-five degrees and lowered at intervals Within a few minutes after this peculiar behavior was noticed a fetus appeared at the cloacal aperture The posterior third of the body of the snake slowly moved from side to side, and a peristaltic wave pushed the fetus backward a few millimeters at a time (Pl LXXVII, Fig 2) When about half extruded, the young snake straightened its neck and thrust its head through the the membranes (Pl LXXVIII, Fig 1), and a continuous wavelike motion of the female's body pushed it smoothly through the remaining distance (Pl LXXVIII, Fig 2) She had not changed the position of the anterior part of her body during the whole process, her only movements, besides those necessary for the expulsion of the fetus, were to flex the neck slightly, and she remained perfectly motionless for twenty minutes afterward The extrusion of the

young snake, from the time of its first appearance until completely outside, was accomplished in slightly less than ten minutes

When abdominal movements began again the snake shifted her position The next fetus moved posteriorly with difficulty, and the snake appeared uncomfortable if not in actual pain As the supposed fetus approached the cloaca it progressed more slowly, and the movements of the female were more labored The tail was elevated at intervals, but dropped after a moment or two of ineffectual straining This behavior continued for nearly two hours, when just before midnight the tail was suddenly elevated and a whitish buff-colored mass appeared at the cloacal opening It paused for about a minute and a half, and then was forced out quite suddenly by a violent contraction of the abdominal muscles The object proved to be a sterile yolk (Pl LXXIX, Fig 1), hard, solid, and of irregular shape The female rested again, resuming the abdominal peristalsis within twenty-five minutes The next fetal mass moved more rapidly and easily toward the cloaca, forty-five minutes after the beginning of the movements a coil of the second young snake appeared beneath the elevated tail, moving forward a few millimeters at intervals of two or three seconds until it was completely extruded (Pl LXXIX, Fig 2), this process likewise took about ten minutes

At birth the young snakes were folded two or three times within the membranes, with their heads toward the middle (Pl LXXVII, Fig 1) The first part presented in the births observed was a bend of the neck Unless the membranes were ruptured during parturition, as in the one case described above, the young of both females made no effort to break through for about forty-five minutes However, those of another brood observed soon after birth remained in the membranes for several hours, but since the day on which they were born was unusually cool and damp, it is probable that the low temperature prolonged their postnatal quiescence for an unusual length of time Lynn (1929, p 97) reports an abnormal case in which a young copperhead remained alive within the dried prenatal membranes for nine days

In emerging from the egg covering the young snakes extended their necks, pushed their heads through the membranes, and after a pause varying from a few seconds to several minutes wriggled out These active movements pulled the short body stalk free of the yolk sac, allantois, and associated structures, but for a short time it re-

mained attached to the ventral body wall ten to fifteen scales anterior to the anus It eventually dried and became shriveled, and was lost during the first ten hours after birth

An egg tooth was present, but obviously of little use in rupturing the thin membranes The egg tooth in a crotalid snake was noted as early as 1857 by Weinland, who found it in *Crotalus Catesbaei* (*Crotalus horridus*) Dunn (1915, p 37) appears to have been the first to record it in the copperhead Beyer (1898, p 20) does not mention it in describing the puncturing of the membranes of *Agkistrodon piscivorus*, although he had observed it in another ovoviviparous snake, *Natrix grahamii* It seems probable that in the

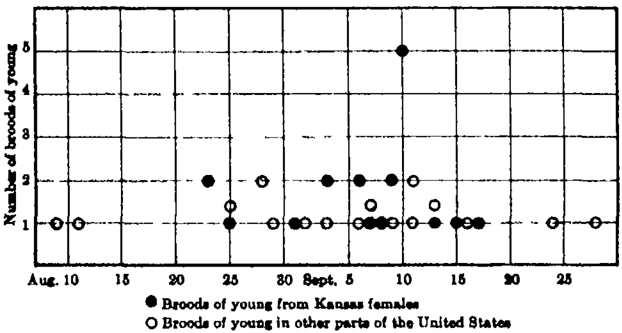

Fig 18 Range and frequency of birth dates in the copperhead

ovoviviparous species this structure, of such vital importance in the groups of snakes which produce tough-shelled eggs, is in the process of phylogenetic degeneracy

Strecker (1926, p 10) records an example of bicephalism in a young copperhead which was born in captivity and lived for two days

Birth dates — In the Kansas material dates of the birth of young ranged from August 23 to September 17 (see Table I) Published records of eighteen broods in different parts of the United States from Louisiana to Massachusetts are available These show a range of from August 9 to September 29 (see Table II) Of the total number, including all available records, all but four fall within the limits of the range of the Kansas series (Fig 18), a period of less than

a month, which, in view of the diversity of climatic conditions represented by such widely separated localities, is remarkably short

Number of young produced — In the twenty broods studied by the writer the number of young varied from two to six (Table I), broods of four were the most common The number of young is available for seventeen of the eighteen published records (Table II)

TABLE I

BROODS FROM KANSAS FEMALES

No of female	Length in cm	Date of birth of young	No of young in brood	Sexes ♀	Sexes ♂
1	61 4	Aug 23 1925	5	2	3
2	59 5	Aug 23, 1925	2	1	1
3	69 5	Aug 24 1925	6	1	5
4	57 0	Sept 3, 1925	4	0	4
5	62 0	Sept 6, 1925	3	1	2
6	65 5	Sept 9, 1926	6	3	3
7	59 7	Sept 13, 1926	4	1	3
8 *	66 5	Aug 31, 1927	5	3	2
9	69 0	Sept 9 1927	6	5	1
10	61 0	Sept 17, 1927	3	3	0
11	63 5	Sept 10, 1927	4		
12	60 5	Sept 10, 1928	4	2	2
13	64 0	Sept 10, 1928	5		
14	58.5	Sept 10, 1928	2	0	2
15	67 0	Sept 10, 1928	6	2	4
16		Sept 6 8 1929	2		
17 †	67 5	Sept 15, 1929	5		
18	65 5	Sept 7, 1931	4	2	2
19	64 6	Sept 3, 1931	4	2	2
20	60 8	Sept 8, 1931	4	1	3

* Abortion

† Found beneath stone on hillside with young apparently stillborn

The range in this series is from three to nine, broods of six occur with greatest frequency

A few more references, less definite but having a certain interest, may also be mentioned Allen (1868, p 179) states that six females killed in September in Massachusetts contained from seven to nine young each Hay (1892 *b*, p 533) quotes Allen (*loc cit*) and discredits newspaper accounts of broods of from sixty to eighty Stejneger (1895, p 405) gives the average number of young as between

seven and nine Mitchell (1903, p 27) reports finding from three to eleven embryos in the uteri of females in Texas Surface (1906, p 189) says that in Pennsylvania from six to ten young are born at a time Ditmars (1910, p 338) states that about a dozen young are produced at a birth, and in a later account (1931, p 102) gives the range as from six to nine Hurter (1911, p 208) gives the usual number as from four to nine and records thirteen embryos in a

TABLE II

SUMMARY OF PUBLISHED RECORDS OF THE BIRTH OF YOUNG

Author and year *	Locality	Date of birth	No in brood
Atkinson (1901 p 153)	Allegheny Co Pa	Aug 28	6
Babcock (1926, p 5)	Blue Hills, Mass	Sept 29	6
Beyer (1898, p 20)	New Orleans, La	Sept 16	7
Brimley (1923, p 115)	Raleigh, N C		6
Ditmars (1896 p 23)	New Jersey (?)	Aug 9	6
do	do	Aug 10	9
(1907, p 425)	New Jersey	Aug 25	6
do	do	Sept 6	5
do	do	Sept 7	4
do	do	Sept 9	6
do	North Carolina	Sept 10	7
do	New Jersey	Sept 10	9
do	Pennsylvania	Sept 11	9
Dunn (1915, p 37)	Haverford Pa	Sept 1	7
Lynn (1929, p 97)	Baltimore Md	Sept 24	7
Reese (1926, p 357)	West Virginia	Sept 13, 15	3
Stadelman (1928 p 67)	Glenolden Pa	Aug 29	8
(1929, p 81)	do	Aug 28	

* Complete references to each of these papers will be found in the literature cited

Missouri specimen captured on July 27 On June 13 Brimley (1923, p 115) examined in North Carolina a female that contained eight eggs with small embryos, and on August 13 another with four larger embryos Stewart (1929, p 11) gives the number of young at from four to nine, and Netting (1930, p 178) as from four to ten Kunze (1883, p 1235) quotes newspaper clippings describing the finding of sixty and sixty-eight young copperheads in the bodies of females, and Funkhouser (1925, p 136) tells of a similar instance in which forty-two embryos were said to have been counted It seems

quite probable that these obviously erroneous reports cited by the last two authors are the results of confusion of the copperhead with snakes of some other ovoviviparous groups, such as *Thamnophis* and *Natrix*

Size of females and number of young — Data based on nineteen females of the Kansas series indicate that in general the larger broods are produced by the larger females This relationship is shown by Figure 19 Unfortunately not enough data are available in

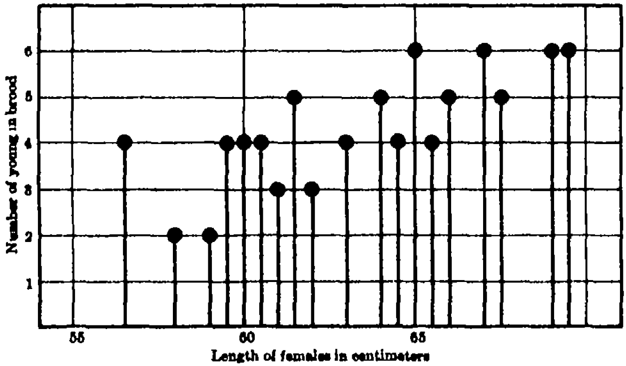

Fig 19 Relation between size of females and number of young produced in a single brood

the published records of Table II to warrant including larger broods of young in the graph and thus making it more nearly complete

Period of gestation — Only an approximation of the gestation period of the copperhead was obtained from these studies Since it is not as yet known just how much time is needed by the spermatozoa to reach the eggs after copulation, the exact period of gestation could not be ascertained even if definite observations on copulation and parturition by the same individual were available However, if the term "gestation" is used in its less strict application as referring to the period between the time of copulation and the time of birth of young, it is possible to estimate the duration of this period from the data at hand It has been indicated above that mating normally occurs in April and early May in the Kansas region, and it has been further shown that young are born in that locality between August 23

and September 17 It has also been shown (Table II and Fig 18) that for the other localities mentioned in the literature all but four of the broods of young fall within these same range limits, a period of twenty-five days, which may be considered approximately equivalent to the length of the breeding season If one estimates the average time of mating as April 15 and the average date of the birth of young as September 4, and at the same times recognizes the probability of variations due to weather conditions, the period between mating and birth of young would be approximately 142 days, or about twenty weeks Since many factors, such as temperature, humidity, food supply, and physiological condition of the individual

TABLE III

SIZE OF NEWLY BORN YOUNG

Data from seven females and eleven males

	Average length in mm	Extremes	Average weight in gm	Extremes
Females	230 7	218–242	10 0	8 3–10 6
Males	237 5	223 247	10 5	8 0–14 0
Both sexes	235 0	218–247	10 3	8 3–14 0

females, might be expected to influence the rate of development of the eggs in a poikilothermous species, considerable variation in the length of the gestation period may be quite normal

Beyer's observation (1898, pp 19-20) of a female believed to have mated on April 11 and known to have given birth to young on September 16, a gestation period of approximately 158 days, may possibly represent a case of delayed parturition due to the fact that the female was in captivity during the entire time It seems worthy of note in this connection that with but three exceptions all the females which gave birth to young in the writer's laboratory were collected during the latter part of August, only a few days before parturition

YOUNG COPPERHEADS

Size and sex ratio — Eighteen young from a series of four broods, including seven females and eleven males, were weighed and measured within a few hours after birth The average length of the two

sexes was 235 millimeters, the average weight, ten grams The averages and the extremes for each sex are given in Table III

Stadelman (1928, p 67) recorded the average length of eight young as twenty-one centimeters and the average weight as six grams

In a total of sixty-nine young of sixteen broods (Table I) 42 per cent (twenty-nine) were females and 58 per cent (forty) were males Among snakes collected in the field a considerable excess of males was usually noted Of 222 copperheads collected in April and May during the years from 1925 to 1929 inclusive about 60 per cent were males However, in two collections from La Cygne, Kansas, in April, 1931, the numbers of snakes of each sex were nearly equal, with the females in very slight excess Of the total of 103 there were 52 females and 51 males More definite knowledge of the sex ratio in this species must await the study of a larger number of broods

Coloration — At birth the young snakes were quite dark, and their skins were glossy (Pl LXXVII, Fig 1) The conspicuous yellow tail frequently mentioned in the literature was dull and clouded After the first shedding of the skin, however, the general color was lighter, the gloss disappeared and left the skin with a soft and velvety texture, and the yellow of the tail became strikingly brilliant

Postnatal food — The semisolid mass of yolk within the bodies of the young snakes caused them to have a decidedly plump appearance during the first few days of their free existence Dissection of four individuals permitted the weighing of the yolk within the first few hours after birth It ranged from 13 8 to 29 2 per cent of the total weight of the snake It was noticeably less on the second day, in two snakes examined at the age of ten days it was reduced to less than half a gram At the age of fifteen days no yolk was present At ages of two to three weeks some of the young fed upon small mice

Ecdysis — In the majority of observations all the young of a single brood underwent their first ecdyses at about the same time In three litters only did the period of molting occupy two or three days The youngest age at which the skin was shed was three days and the oldest ten days, the greater number of young observed shed on the seventh or eighth day

Babcock (1926, p 5) reported ecdysis in a copperhead six days old, and Lynn (1929, p 97) states that six of a litter of seven shed at the age of twelve days

Secretion of the caudal glands — The caudal glands, which in

adult copperheads produce a secretion with a decidedly penetrating odor, were not active in the very young After they had reached the age of eight days, however, a few droplets of clear liquid, with traces of the characteristic odor, were obtained when a gentle pressure was applied at the base of the tail One individual of this age ejected a fine stream a distance of about an inch In adults the secretion is well developed and is much in evidence when the snakes are irritated by the firm hold of the neck which, for the safety of the operator, is necessary when measuring live snakes or extracting venom A fine jet of this liquid is sometimes shot out to a distance of two or three feet from the duct of each gland Under these circumstances it seems to be used in self-defense as a repellent It appears that the morphology and physiology of the caudal glands of snakes have not been carefully studied

Venom — Small clear drops of venom, light amber in color, could be extracted by gentle massage from snakes five days old, and some voluntarily killed and fed upon small mice when a little over two weeks old

That the venom of the very young of poisonous snakes is more or less dangerous was maintained by Beyer (1898, p 21), who suffered intensely from the bite of a ground rattler (*Sistrurus miliarius*) eight days old, although after the bite of a day-old cottonmouth (*Agkistrodon piscivorus*) he felt only a sensation comparable to that of a bee sting Atkinson (1901, p 153) wrote of having been bitten on the finger by a copperhead eight days old He also suffered from a painful inflammation which continued for four days

The potentialities of the venom of very young snakes have been recently discussed by several writers Reese (1926, p 357) made some observations which he thought indicated that copperheads a month old were incapable of poisoning other animals, although their fangs and venom glands were well developed Viosca (1926, p 328) quoted Beyer and offered the suggestion that in young poisonous snakes the venom may not be secreted until after the first day Stadelman (1928, pp 67 69) reviewed the comments of some of the previous writers and from tests made on a mouse and on himself concluded that copperheads only six hours old were in possession of a completely functional venom apparatus capable of inoculating a dangerous amount of venom, particularly if the victim is very young or in poor condition

With the desire to test the strength of the venom the writer caused a young copperhead, within an hour after birth, September 10, 1928, to bite the left hind leg of a twelve-gram albino mouse Both fangs were embedded in the flesh, but no pressure was applied, care was taken not to increase the amount of venom beyond that which the snake would independently inject A small drop of bloody serum or lymph oozed from one of the punctures Within one minute pronounced edema and discoloration appeared on the bitten leg, and the sole of the foot darkened from the normal pink to a dark purple The swelling and discoloration caused by the extravasation of blood continued up the leg and thigh, and within eight minutes the leg was paralyzed At fourteen minutes the edema and darkening included the entire leg and the adjacent part of the body The mouse died in slightly less than an hour Post-mortem examination revealed great subcutaneous extravasation in the entire leg and sacral region The heart and lungs were darkened and congested, and the large blood vessels appeared to be clogged This experiment was repeated with another snake and a second mouse, the same typical symptoms of crotalinic poisoning took place and death resulted in one hour and thirteen minutes

Stadelman (1929, p 81) later obtained similar results under somewhat comparable conditions, but with death not resulting until *forty-eight* hours after the bite, presumably because a larger mouse was used, although the size was not stated

SUMMARY

1 Observations made in the field and microscopical examinations of the genital tracts of both sexes at different times of the year indicate that mating in the copperhead normally occurs soon after the snakes emerge from hibernation In eastern Kansas this takes place during April and early May

2 Gravid females collected at various times from July 14 to August 30 showed a certain gregariousness, two or three appeared to have been drawn together by an especially desirable shelter Pregnancy was indicated at this time by the enlargement of the posterior third of the body

3 The young of two females observed in parturition were expelled at intervals of approximately one hour, the time for the extrusion of a single fetus was about ten minutes

4 Unless the prenatal membranes were ruptured in passage through the cloaca of the female, the young snakes usually remained quiet within them for nearly forty-five minutes

5 The egg tooth appeared to be unnecessary for the rupturing of the embryonic membranes

6 Young copperheads in the Kansas region were born in the late summer and early fall, between the dates of August 23 and September 17, about twenty weeks after the probable time of mating

7 The number of young in twenty Kansas broods ranged from two to six, the larger females had the larger number of young

8 Young snakes at birth averaged 230 mm in length and 10 0 gm in weight for females, and 237 mm in length and 10 5 gm in weight for males

9 In the young of sixteen broods 42 per cent were females and 58 per cent were males

10 The postnatal yolk within the body cavity gradually decreased from the first day after birth and was completely absorbed in fifteen days

11 The first ecdysis took place at ages varying from three to ten days, the majority of young shed on the seventh or eighth day

12 The caudal scent glands did not appear to become functional until the young snakes were eight days old

13 Within an hour after birth young copperheads possessed enough venom to cause the death of twelve-gram albino mice, from the glands of some venom could be squeezed at the age of five days, and some killed and fed upon small mice within three weeks

UNIVERSITY OF MICHIGAN

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PLATE LXXVII

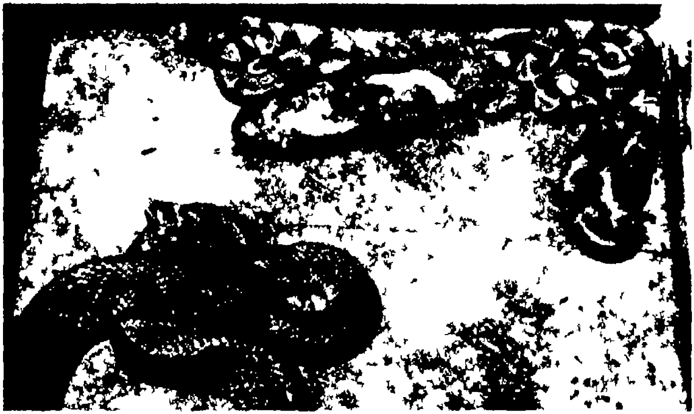

FIG. 1. Female copperhead and newly born brood. Note yolk sac and mass of embryonic membranes from young at upper right, and glossy skins of young which have emerged from the membranes.

FIG. 2. The beginning of parturition in a second female. The head of the young snake has not yet appeared.

PLATE LXXVIII

Fig. 1. Female copperhead shown in Plate LXXVII, Fig. 2. The young ... has pushed its head through the egg membranes before being comp...

Fig. 2. Same female after birth of the first young snake

PLATE LXXIX

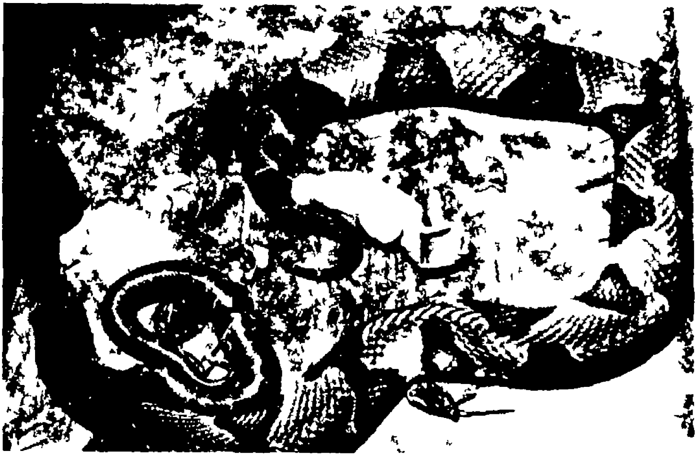

FIG. 1. Female copperhead shown in Plate LXXVIII. The hard, misshapen, sterile egg was extruded with great difficulty.

FIG. 2. An apparently normal birth, showing the young completely expelled with embryonic membranes intact.

A STUDY OF THE GENERAL BIOLOGY, MORPHOLOGY OF THE RESPIRATORY SYSTEM, AND RESPIRATION OF CERTAIN AQUATIC *STRATIOMYIA* AND *ODONTOMYIA* LARVAE (DIPTERA) *

KIMBER CLEAVER KUSTER

INTRODUCTION

IN RECENT years very little has been done, especially in this country, on the biology of *Stratiomyia* larvae. The excellent publications of Swammerdam (1737–38, 1758), Réaumur (1738), and Miall (1895) on the aquatic form "*Stratiomys*" *chamaeleon* were so thorough and so excellent in quality that, evidently, few investigators thought it worth while to attempt further study. However, the workers mentioned above did not exhaust the possibilities for research in the field of either the morphology or the physiology of these insects. The taxonomy of stratiomyiad adults is now in a relatively satisfactory condition, but the classification of the larval stages is still quite imperfect.

The peculiar habits and structures of certain aquatic stratiomyiad larvae make them especially favorable for the study of respiration. Larvae are generally abundant and cosmopolitan in regions where fresh-water ponds and slow-running streams abound. Under conditions of normal rainfall larvae occur in great numbers in the small lakes and ponds, and in the Huron River in the vicinity of Ann Arbor, Michigan.

A thorough morphological study of the tracheal systems, spiracles, and accessory respiratory structures of several species was necessary before engaging in experiments on the physiology of respiration. An attempt was made in this investigation to determine the method of respiration of these larvae by both morphological and experimental

* Contributions from the Department of Zoölogy of the University of Michigan.

approaches In addition to the major work on the structure and function of the respiratory system of these larvae, numerous data on their general biology have been secured The results included in this paper were obtained during the period from March, 1928, to March, 1932

ACKNOWLEDGMENTS

The author wishes to record his indebtedness to Professor Paul S Welch, under whose direction this investigation was made Acknowledgment is due also to Dr J M Aldrich, associate curator of insects, United States National Museum, and to Mr C T Green, Bureau of Entomology, United States Department of Agriculture, for identification of specimens, to Mr Frederick M Gaige, director of the Museum of Zoölogy, University of Michigan, for the use of rare books from his private library, and to various other persons for material and assistance

HISTORY

Early records of the Stratiomyiidae date back to the work of Aristotle Very early these flies were confused with the tabanids Aristotle [1] recognized the two groups as distinct, and Mouffet (1658) rails against the authors who confuse stratiomyiads with *Tabanus*, but this confusion apparently persisted for another century In the classic, *Bybel der Natuure*,[2] by Swammerdam, an attempt is made to establish the name "*Musca asilus* or Gadfly" for the common European "*Stratiomys*," thus distinguishing it from *Tabanus* This splendid work deals with the general biology and the external and internal morphology of the larva, pupa, and adult of "*Stratiomys*" *chamaeleon* Special emphasis is placed on the structure of the digestive and respiratory systems and their transformation during metamorphosis In general, the accuracy of Swammerdam's observations is astounding, considering the circumstances under which the work was done His contemporary, Réaumur (1738), independently made almost the same observations regarding the habits and structures of these flies Réaumur's plates indicate that a number of species representing several genera were studied This work stresses a classification of his

[1] *Historia Animalium*, 5 19, 551 b, 8 10 596 b In the Oxford translation of this work a note on the former reference distinguishes between the tabanid and the gadfly

[2] In the following pages all references are to the 1737–38 edition of Swammerdam's work.

own making From time to time data on the natural history of these flies were added until Miall (1895) devoted a chapter to "*Stratiomys*" in his *Natural History of Aquatic Insects*, and Hart (1895), in this country, made a splendid contribution to the life-histories of a number of the common species of *Stratiomyia* and *Odontomyia* from the Illinois River Henneguy (1904) and Berlese (1909) copied the figures of Swammerdam and others without adding original information Miall (1895) included some of Swammerdam's figures, Hart (1895) used only original figures

With regard to the name *Stratiomyia* the following record is of sufficient interest to be mentioned Geoffroy (1762) first established the genus "*Stratiomys*" Osten Sacken (1878) claims that Geoffroy, in translating Réaumur's "Mouche armée," evidently intended the name to be *Stratiomyia* and not "*Stratiomys*" Loew (1865) amended the genus name "*Stratiomys*" to *Stratiomyia*, which still prevails

Methods

Collection

Collections were made with a long-handled dip net, or the material in which larvae were known to be present was sorted by hand Sometimes it was very profitable to skim the surface of a pond or the margin of the river with the dip net and take to the laboratory the débris containing the larvae At other times it was most convenient to sort the specimens from the débris in the field

The larvae of *Odontomyia cincta* Olivier and *O virgo* Wiedemann occur at the surface of shallow pools and margins of streams or crawl about in damp moss, loose bark, and decaying wood, and also in débris of dried-up ponds *Stratiomyia discalis* Loew, *S norma* Wiedemann and *S lativentris* Loew were found in the muck along the shore of the Huron River below the outlet of a city sewer The larvae of *Stratiomyia* seemed to prefer abundance of decaying organic matter well shaded by cat-tails and other plants

Moss and débris brought into the laboratory were allowed to dry Reduction of moisture caused the larvae to crawl about freely, thus making them easily seen

Culture

When larvae of *Odontomyia cincta*, *O virgo*, *Stratiomyia discalis*, *S norma*, and *S lativentris* were brought in from the field along with

habitat material, cultures were made, in containers of various sorts, to correspond as nearly as possible to the conditions in nature. Tap water, cistern water, and water from the source where the larvae had been collected were used separately in these cultures. Glass covers prevented the escape of larvae, and ventilation was effected by placing a towel under the cover.

In these cultures larvae grew and pupated, and adults emerged. Larvae were also isolated in small, covered stender dishes, some with water and others without water. Usually, the last larval instars were selected for isolation in order to obtain the final exuviae when the imago emerged. It is important that only very little water be in these small containers at ecdysis. Excess moisture has no deleterious effects on ecdysis itself, but the newly born fly is often permanently maimed by getting wet. The wings inflate and harden best in a dry circulating atmosphere. Wings that happen to get thoroughly wet before complete inflation seldom are perfect when dry. Sometimes, too, mold develops about the anal and respiratory orifices. This infection is usually fatal. Occasionally most of the larvae in a given locality are destroyed by parasitic Hymenoptera.

Larvae will thrive for months in foul débris, in fact, as long as they get air for respiration and plenty of food. Although they respond to light and temperature, they are not seriously affected within the limits of ordinary laboratory conditions. It is possible to keep the last instar larvae without food from late fall to the following spring. One larva of *O. cincta*, taken on October 8, was kept, on the writer's desk, in water with a small branch of Chara until April 18, when a perfect fly emerged. The Chara disintegrated slightly, and water was added several times. For weeks at a time this larva was not observed to move from its position in the stender dish. Although the laboratory was warm throughout this period, the larva rested on the bottom, completely submerged. When picked out of the water, it would slowly bend to a crescent shape, drawing the tip of the abdomen up toward the head. It would very slowly straighten out when returned to the stender dish and remain on the bottom as if dead. At the time of pupation it came to the surface of the water and stayed there until metamorphosis had been completed. Swammerdam's figures of the characteristic shape of the larval skin inclosing the pupa made it possible easily to distinguish the pupa from the larva.

All attempts to have these flies mate and oviposit in the labora-

tory were futile Pairs of adults were placed in a large breeding cage containing a dish filled with water Small branches and flat pieces of wood were stood in the water and allowed to lean against the inside of the cage It was hoped that these objects would serve as supports for the attachment of egg masses In bright sunlight the flies were quite active, continually making an effort to escape Although cane sugar, fresh fruits, and syrup were available for food, the flies soon died Some, however, were seen to dissolve crystals of sugar with saliva and ingest them This was the only feeding of imagoes observed

TECHNIC

Microscopic technic

Material for microscopic study was prepared in several ways for sectioning Since the tough, hard integument of the larvae resisted the penetration of fixing fluids, clearing oils, and embedding materials, work was done, not with the larva as a whole, but with individual, excised somites Tissue embedded in Johnson's special India rubber, paraffin, and asphalt mixture (1903) sectioned much better than in pure paraffin Even with the added toughness due to rubber in the block containing the tissue perfect serial sections were seldom obtained

The best results were obtained by fixing individual, isolated somites of larvae in Carnoy and Lebrun's fluid (Lee, 1928), and embedding in paraffin, the melting point of which was 48–50 degrees centigrade Cedar wood oil was employed for clearing the tissue Long staining in a weak solution of magenta red gave excellent results, which, however, were of a temporary nature, since the color is fading in all sections Serial sections were cut 5 to 20 microns thick

Imperviousness of the skin was well illustrated by a larva which was submerged for 23 hours in a 5 per cent solution of sulphuric acid, with no apparent ill effects Another larva was alive after 2 hours and 25 minutes in concentrated potassium hydroxide To remove calcium salts, which often impregnated the integument, live larvae were dropped into 2 per cent hydrochloric acid until effervescence ceased A bath in tap water was followed by submerging them for 20 minutes in 10 per cent warm potassium hydroxide to soften the chitin The acid and hydroxide stimulated activity on the part of the larvae, but apparently caused no injury

Gross technic

Stained oil dissections

Attempts were made to fill the tracheal system of larvae with stained oils for the purpose of making the small tracheae more readily visible Like Hacker (1925), the writer obtained the best results with kerosene plus Sudan III and with xylol plus Sudan III Vegetable oils, such as olive oil, were much too viscous These stained oils entered the posterior spiracles and partly displaced the gas in the tracheal system Complete displacement never occurred in a single specimen However, by combining the results from all the larvae subjected to the stain a composite whole of the tracheal system was made Living larvae were submerged in the two oils mentioned until after activity had ceased This method of making the tracheae apparent with stained fluids was effective only with young larvae Larvae in the last instar have perfect control of the respiratory chamber, so that stained oil does not enter in sufficient quantity to be useful Since all the morphological studies were made of mature larvae, a more satisfactory technic was necessary to render the tracheae visible

Glycerine dissections

Wahl (1900) injected pure glycerine into the haemocoele of living *Eristalis tenax* larvae with good results The writer, instead of injecting glycerine into the body cavity, made a series of punctures in the integument and then submerged the larvae until the body fluid had been replaced by glycerine To relax the larvae before submerging them concentrated chlorotone was injected with a very fine hypodermic needle into the haemocoele dorsad to the ganglia The tracheal system remained fully inflated with gas while submerged, and could be preserved in this condition for future dissection

Dissections were made in shallow stender dishes half-filled with paraffin The paraffin provided (1) a suitable surface upon which to pin specimens for dissection, and (2) a white background for making photographs Larvae were held in place for dissection by means of small sharp pins passed through the head and last somite After the specimens were relaxed, they were always kept submerged in glycerine

Gross dissections were made to show the dorsal and ventral

aspects of mature larvae of both *Stratiomyia* and *Odontomyia*. In either exposure right and left lateral incisions were made through the integument from the head to the last somite. A transverse incision joining the two lateral incisions was made back of the head. While the cut edge of the body wall, produced by the transverse incision, was gently lifted with forceps, the tissue beneath was slowly separated from the body wall with a small knife. As this operation progressed pieces of the freed wall were snipped off until the upper surface of the thoracic and abdominal regions had been completely exposed. The integument of specimens that had been thoroughly infiltrated with glycerine separated very readily from the soft tissue beneath without disturbance or injury to the finest tracheae. If the tracheal trunks or tubes were cut or even slightly punctured, glycerine slowly entered and gradually filled the system; otherwise, they remained full of gas.

The method of preserving these dissections was discovered by accident. Three dissections were made on September 22, a very warm day. Uncompleted observations made it necessary to keep them for subsequent checking. Plenty of glycerine was added to the specimens, and they were put into an electric refrigerator at a constant temperature of 5 degrees centigrade. The visibility of the tracheae has remained perfect in two specimens for a period of more than twenty-seven months.

Photographic technic

Motion pictures of active young larvae in water, photomicrographs of the plumose hairs of anesthetized larvae and dissections of the tracheal system, and large photographs of dissections were made. A Sept motion picture camera was employed, which used an Eastman film 35 mm. in width. Exposures were made through the side of a glass jar filled with water which contained the swimming larvae. The results and purpose of these pictures will be discussed later in this paper. Pictures of the plumose hairs were obtained by photographing *Odontomyia* larvae which had been anesthetized with either chloroform or ether. A Zeiss "Phoku" photomicrographic ocular was used on a compound microscope. Each larva was suspended at the surface of the water by its corona of hairs. In spite of the reflection of light from the water a series of good profile views of the posterior end of the larva was obtained by transmitted light.

Biology of the Larvae

Habitats

Representatives of the two genera of larvae discussed in this paper were collected in two distinct habitats *O cincta* and *O virgo* were obtained in small shallow pools in hardwood forests and in sphagnum of the tamarack zone of a swamp These larvae thrive in open water partly shaded either by trees on the bank or by aquatic plants When the pools dry up during the summer the larvae crawl into the moist bottom muck, under bark of fallen trees and branches, and in moss covering the shore and objects normally submerged The water in these pools usually becomes foul from decomposition of organic matter and often completely disappears through evaporation During periods of drought and throughout the winter these larvae remain in moist, well-aërated situations. In the pond habitat they move freely from open water to moist débris on the shore, or from the shore into the water In the swamp both species were taken in the damp sphagnum covering stumps, fallen branches, and small hummocks

The Huron River provided an entirely different situation Owing to a dam, water level in that part of the river where collecting was profitable remains constant The current is very slight, abundant sewage waste fouls the water and collects along the narrow littoral region In the mud and decaying organic matter of this narrow zone the larvae of *Stratiomyia discalis* Lw , *S norma* Wied , and *S lativentris* Lw occurred Specimens were most plentiful in the muck and débris among the cat-tails and other plants which furnish shade Partly submerged pieces of wood covered with débris were common situations for these species

Adaptations

Larvae of *Stratiomyia* and *Odontomyia* used in these observations are somewhat amphibious, since they can live for days at a time either submerged in water or entirely without water They are air breathers with spiracles and an extensive system of tracheae When a larva is at the surface the exchange of gas with the atmosphere is quite regular, but when it is submerged it must draw on the oxygen supply already in the tracheal system, as will be shown in the discussion of respiration The great volume of gas held by the tracheal trunks is

adequate for long periods of time, especially when the larva is inactive and the temperature is low In the absence of water this same system functions perfectly Adaptation of the tracheal system to permit extended periods of submergence is certainly advantageous to air-breathing larvae which are aquatic feeders

The single pair of spiracles situated at the bottom of the respiratory chamber and completely inclosed by the body wall of the last somite is splendidly adapted for screening air and preventing the passage of liquids into the tracheal trunks In conjunction with the respiratory chamber and its orifice the spiracles form a morphological adaptation for insuring the admission of air free from foreign particles and the exclusion of undesirable fluids Since these larvae live in habitats where accidental submergence is quite likely to occur, and where débris and disintegrating materials are prevalent, these two adaptations are very important

Swammerdam described the integument as of a shagreen texture The epidermis consists of hexagonal, calcareous cones, the apices of which extend into the laminated dermis Miall (1895) ascribes the flexibility of the skin to the slight bending between these cones The calcareous cones give a hard surface to the larval skin, and the dermis is responsible for its toughness and strength The skin is much thinner in the intersegmental regions, where the greatest movement occurs The remarkable adaptation of the integument lies in its pronounced impenetrability, both to sharp piercing objects and to fluids It has long been known that "*Stratiomys*" larvae are not readily killed in "spirits of wine," and it has already been mentioned that larvae can endure sulphuric acid and potassium hydroxide for hours without fatal results The author used 70 per cent alcohol to preserve larvae, and discovered that many survived after a period of twelve hours' continuous submergence Larvae may crawl about in ether or chloroform for several hours without being anesthetized sufficiently to prevent muscular contraction during dissection When these reagents do affect larvae, it is quite probable that they enter primarily through the openings to the digestive tract and respiratory system, and not through the skin

With such a substantial covering these animals apparently have few hazards from small predatory enemies, floods, or droughts Representatives of several genera of parasitic Hymenoptera are known to attack young larvae

LOCOMOTION

Swammerdam mentioned that the "worm" of "Asilus carries its legs within a little snout near its mouth" The structures mentioned are a pair of palps, which lie in clefts on either side of the ventral surface of the head They are armed with hooks and hairs and function both in locomotion and in feeding The palps vibrate almost continuously, even when the animal is suspended from the surface film These structures are not legs but mouth parts, used as accessory locomotor organs

In crawling on a firm slightly rough surface the caudal end of a larva remains fixed while the body is extended, carrying the cephalic portion forward, then the cephalic end remains fixed in position while the body contracts, bringing the caudal portion forward The palps and the rostrum anchor the cephalic end while the caudal portion of the body is brought forward Hooks and hairs on the ventral surface of the abdominal somites anchor temporarily the posterior portion while the anterior portion progresses Some *Odontomyia* larvae have strong hooks on the distal rim of the sixth and seventh abdominal somites, but not on the eighth somite, others have weaker hooks on the fourth to the seventh somites inclusive These hooks are directed forward and are of use in maintaining the position of the posterior portion of the crawling larva

On a smooth surface larvae progress by rolling and squirming Since the greatest diameter of the body is in the region of the metathoracic and first abdominal somites, the larva will not roll like a perfect cylinder, thus contortions of the body, due to contraction and bending, give a rather undirected course of progression However, larvae placed on glass, under the heat and light of an electric bulb, manage to get away from the spot of greatest discomfort by rolling and squirming

Locomotion in water consists of moving about on the bottom and over submerged objects, rising from the bottom, and swimming at the surface

The specific gravity of these larvae is quite variable, usually being less than that of water They seem to be able to change their specific gravity to suit their needs, for they move about over the bottom and submerged objects or rise to the top at will Beneath the surface they progress with a smooth gliding movement, owing to the

rapid alternating vibration of the palps The center of gravity is in the anterior end and keeps the head down just enough to allow the palps to vibrate on the substratum and move the body It was the observation of this type of locomotion that led Swammerdam to refer to palps as legs

Ascent to the surface (text Fig 20) is a flotation process related to respiration and will be discussed in the experimental section of this paper It is sufficient to say here that larvae resting below the surface expel from the respiratory system gas which collects as a large bubble and is held by the plumose hairs on the tip of the abdomen Eventually, the bubble becomes large enough to float the larva to the surface While rising from the bottom the larva generally assumes a sigmoid shape, with the posterior end uppermost It may wiggle as it slowly rises

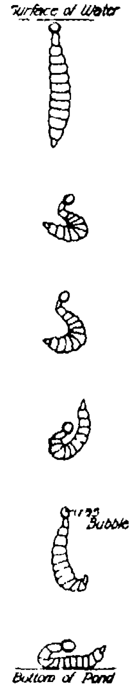

FIG 20 Diagram of a larva with a gas bubble, rising to the surface of the water

Swimming at the surface involves both the effect of surface tension upon the caudal plumose hairs and the irregular movements of the body With the corona of hairs spread funnel-like on the surface the surface tension is great enough to float the larva with the body suspended, head downward, at various angles Progress is made by a slow ventral flexion of the body followed by a sudden twist, which turns it completely around These movements are repeated, with the larva turning sometimes to the right and at other times to the left, and they cause it to move along an irregular course In spite of the sudden twist the corona glides at the surface These larvae, especially the young ones, are very supple Their movements in water are exceedingly graceful when compared with the clumsy crawling method of locomotion on solid substratum

FOOD

Swammerdam found that "clay and soft earth are the food of this insect" He was puzzled by the presence of "little red stones

and small grains of sand" mixed with the digestive products in the intestine From the size of the mouth he was sure that they had not been swallowed and concluded that they had been formed from the food sucked into the stomach Miall (1895) makes one brief statement " the food consists of microscopic organisms swept into the mouth by the palps" Hart (1895) mentions *Stratiomyia norma* Wied as "seeming to browse upon the minute life" occurring on branches of Ceratophyllum The stomach contents of one larva of the species *Odontomyia cincta* "seemed to be mostly mud with a little vegetable matter, and here and there a diatom frustule" The author has observed both young and mature larvae feeding on the soft tissue of dead leaves, from deciduous trees, that had dropped into the pool at least one season before In the laboratory larvae would clean the soft tissue from a leaf, leaving nothing but the venation Soft, decaying wood and bark are often favorite food materials in the natural habitats as well as in cultures In one particular instance the soft wood between the hard annual rings was eaten out by larvae of *O cincta* and *O virgo* It is quite probable that bacteria and other minute organisms, both plant and animal, are also food for these larvae

RESPIRATION

Since respiration of stratiomyiad larvae is one of the major divisions of this work, it will be discussed under the heading "function of the respiratory system"

OVERWINTERING

The mature larvae of *O cincta* and *O virgo* have been found after the snow and ice had melted from the ponds in spring The taking of small young larvae, presumably of both species, at the same time indicates that larvae in both stages of development overwinter in this latitude Hart (1895) states that a large percentage of the larvae of *O cincta* collected in December, February, March, and April, along the Illinois River, were quite young

The presence of larvae in the water as soon as the ice thaws leads one to believe that they spend the winter in the pools or very near to them The last larval instar of *O cincta* and young larvae of *O virgo* have been found in moss and débris above the water level of pools and swamps Scores of *O cincta* were collected in sphagnum

on November 10, 11, and 20, 1930, and again in the same situation on April 2, 1931 Freezing weather and snow prevented later collecting in November On April 2 only the upper layer of sphagnum had thawed, an indication that the temperature in the moss had not risen much above freezing Inactive larvae were found in the moss above the ice in identical places where other larvae had been collected the previous November There is every reason to believe that these larvae had not moved during the winter, but hibernated in the sphagnum

Where the moss was thick, the larvae generally occurred one or two inches below the surface in loose, well-aerated, and moist situations above normal water line A thin covering over logs, stones, or the shore itself often harbors larvae When compact and water-soaked, moss was less frequented than when loose and aerated In several instances specimens were found frozen in débris among the surface irregularities of rotten wood covered with moss In November *Stratiomyia* larvae were found in gravel, six inches above the water line of the Huron River The situation was moist, but not very wet Although there had been freezing weather the larvae were not frozen

Larvae survived freezing of the cultures containing them, both in refrigerators and on the window sill of the laboratory The exact temperature was not obtained, but it was low enough to congeal the débris and water One might well conclude that in both young and mature stages these larvae may spend the winter above the water and that they can survive exposure to temperatures below freezing

EXCRETION

Since the time of Swammerdam it has been known that the larvae of "*Stratiomys*" possessed four "vascula varicosa," or caeca, containing milky white fluid These caeca have been identified as Malpighian tubes, and their function has been determined as excretory by subsequent investigators Vaney (1900, 1902) found calcium carbonate in the tubes of "*Stratiomys*" larvae For a number of years there was some question whether the anterior pair of tubes, or the posterior pair, or both pairs, did the secreting Pantel (1914) claimed that he had found calcium carbonate in all the tubes and that it is an ordinary product of excretion Keilin (1921) confirmed

the work of Vaney and Pantel with reference to excretion of calcium carbonate by the Malpighian tubes of *Stratiomyia* larvae and suggested that it might be a product of respiration

While working with the larvae of *O cincta* the author observed that the Malpighian tubes contained a number of substances varying from a milky white fluid to large, solid concretions, which caused the walls of the tubes to stretch beyond their normal diameter The tubes of some animals contained an amorphous, chalky material, either white or tinged with yellow, and occasionally extending into the hind gut Other specimens had opalescent bodies resembling pearls scattered in the tubes in a haphazard manner These were apple-shaped, almost spherical, or hemispherical Individual concretions varied a great deal in size, and frequently numbers of them were firmly cemented together, resembling in arrangement a cluster of grapes These opalescent individual concretions and clusters resisted pressure applied with a dissecting needle as if they were glass beads, and crushed with distinct cleavage They are heavy enough to collect in the bottom of a dissecting dish while the débris is removed and the water decanted Opalescent concretions occur in the hind gut as well as in the tubes

In addition to the substances already mentioned crystals were found both in the tubes and in the body cavity Those in the tubes formed plugs which filled the lumen and usually were two or three times as long as their diameters These cylindrical plugs had rounded ends, and the sides were corrugated parallel to the long axis They consisted of a series of slender prismatic crystals arranged in palisade formation These crystalline plugs were translucent and varied from straw color to brown In one instance two plugs were separated by soft, white, noncrystalline material In addition to these plugs small, square, transparent crystals occurred both in the tubes and in the haemocoele These were hard and clear, like glass

The fact has been quite well established that insect larvae which feed on putrefying material produce large quantities of calcium salts which are dissolved at the time of pupation and at least partly reformed prior to ecdysis The reformed products are left in the puparium However, not all the secretions of the Malpighian tubes are retained and dissolved during metamorphosis The larvae of *O cincta* have been seen to void milky white excreta It could not be confused with the dark fecal matter and, when treated with

hydrochloric acid, it effervesced, liberating carbon dioxide Voiding of other excretory products has never been observed, although a number of small opalescent bodies, like those common in the tubes and hind gut, were found in a culture dish containing active larvae There is no doubt but that they had been eliminated through the anal aperture

Not all larvae collected in the same pool and at the same time contained concretions Adults were not examined, but both pupae and larvae possessed them, especially those larvae that had overwintered One larva collected in July contained more than 186 individual concretions as well as chalky material Many were cemented together, which made definite counting impossible without destroying the clusters They were the translucent, opalescent, and straw-colored varieties, and they ranged in diameter from 0 04 to 0 5 mm inclusive The larva taken in July was about ready to pupate when it died

A number of tests were made to determine the carbon dioxide content of the gas produced when concretions were treated with hydrochloric acid The methods employed by Krogh (1908) were used in making these determinations Although the series of tests was small, the results were diverse One concretion produced gas which contained 88 2 per cent carbon dioxide In another test three concretions from the same larva produced gas of which 56 2 per cent was carbon dioxide

METAMORPHOSIS

Stratiomyiidae are a border-line family between Nematocera and Brachycera They are classed in Brachycera because of the antennal structure of the adults, but Miall (1895), speaking of "*Stratiomys*," says "It is the simplest in structure and life-history, and the most like a Nemoceran, of all the Diptera which retain the larval skin as the outermost covering of the Pupa" Réaumur (1738) and Swammerdam described pupation and ecdysis in species belonging to the family Stratiomyiidae Swammerdam says that he has "often seen this worm in the space of twelve hours change into a nymph"

The time required for the change from an active larva to a pupa is variable The mature larva gradually becomes inactive and rigid Inactivity is followed by a downward bend in the intersegmental region between the fifth and sixth abdominal somites and an upward

bend in the intersegmental region of the seventh and eighth abdominal somites These permanent flexions indicate that pupation has begun The pupal stage lasts but a few days when the weather is warm During the pupation period the animal becomes much smaller and occupies only part of the cavity in the larval skin This newly formed pupa pulls loose from the body wall at the caudal end, leaving the respiratory chamber and the posterior spiracles in position, and vacating the fifth, sixth, seventh, and eighth abdominal somites, which fill with air In the anterior end most of the first thoracic somite is vacated, and it, also, fills with air These two pockets of air within the skin serve to float the inclosed pupa and provide a pneumatic raft for the imago when it emerges

When the larva shrinks from the integument to form the pupa the lining of the hind gut remains attached to the larval skin In the anterior end the spiracles with portions of the tracheal trunks and the pharyngeal lining are retained, along with the head capsule and cephalic appendages A thin membrane which covers the pupa is left in the larval skin when the adult emerges. This pupal skin contains parts of the tracheal system As the pupa develops the head and thoracic regions swell, inflating the puparium to its limit Transformation from functional larval structures to organs and systems for the adult is rapid

The puparium eventually bursts sagittally along the dorsal surface of the mesothoracic and metathoracic somites and part of the first abdominal somite At each extremity of the sagittal slit a transverse slit occurs Through this I-shaped opening the imago emerges, leaving the pupal exuviae in the larval skin Ecdysis may take place either from a floating puparium or from a perfectly dry one The process of emergence, hardening of the body, and inflation of the wings have been described in detail by Réaumur (1738) and Swammerdam

Morphology of Respiratory System

The *Stratiomyia* and *Odontomyia* larvae used in the investigation of the morphology of the respiratory system have metapneustic respiratory systems Two main tracheal trunks extend the length of the body, terminating craniad in a small pair of dorso-lateral spiracles on the prothoracic somite, and caudad in a pair of large spiracles situated in the respiratory chamber in the last abdominal

somite There is no experimental evidence that the anterior pair of spiracles is functional Long lateral trunks, smaller in diameter, laterad and parallel to the main trunks, arise near the cephalic end of the main trunks and terminate in them at about the middle of the last somite Commissures and tubes connect these tracheal trunks to form a more or less double system for the circulation of gas

The respiratory chamber, which contains the posterior spiracles, is situated in the last abdominal somite The orifice to it is a transverse slit at the tip and is surrounded with plumose hairs Swammerdam, Miall (1895), and Hart (1895) all claim that, with the exception of the mesothoracic somite, each body somite has a pair of spiracles Miall adds that "branches from the longitudinal air tubes pass to them on the inside" The question of whether these larvae have more than two pairs of spiracles will be discussed later

RESPIRATORY CHAMBER

Since the main opening to the respiratory system is in the tip of the last abdominal somite, the structures of this region will be described first The respiratory chamber is a membranous sac completely inclosed by the body wall of the last one fourth of the somite Entrance to the chamber is through a transverse orifice in the end of the abdomen Accessory structures consist of plumose hairs surrounding the orifice and a pair of air sacs extending craniad from the floor of the chamber Each will be described in detail, separately

Morphology of plumose hairs

The plumose structures (Fig 23 *ph*) surrounding the respiratory orifice have been called hairs by Swammerdam and bristles by Wahl (1900), when referring to similar structures in *Eristalis tenax* L Henneguy (1904) and Berlese (1909) both called them "rigid, chitinous filaments" forming a "caudal corona" in "*Stratiomys*" *chamaeleon* larvae Dunavan (1929), working with *Eristalis arbustorum* L, called them "feather-like setae" The terms "hairs," "bristles," and "setae" have been used promiscuously for this circle of structures attached to the dorsal and ventral rims of the opening to the respiratory chamber According to Imms (1925), these structures should be classified as "plumose hairs," under the broad term "setae" The mature structures conform to the definition of hairs and not of bristles However, since the development of the Stratio-

mylidae has not been traced from the embryo through the various instars of the larva, this matter cannot be settled positively at this time

These plumose hairs occur along the crescent-shaped dorsal and ventral rims of the tip of the abdomen just back of the chitinous blades which guard the orifice to the respiratory chamber They vary in number, as indicated in the following table

TABLE I

OF PLUMOSE HAIRS IN CAUDAL CORONA

Species	Hairs in dorsal rim	Hairs in ventral rim
O cincta	24	40
do	27	36
O virgo	24	40
do	26	36 +
do	28	28
S norma	23 +	22 +

The hairs of *O cincta* are most readily counted although very small hairs, sometimes interspersed among large ones and near the ends of each crescent, are easily overlooked It is very difficult to count hairs on *S norma* because the long ones are few and the small ones abundant There is a marked tendency in some species for these hairs to occur in a series of tufts, each tuft consisting of long, large hairs separated by one or more small ones The hairs on the ventral side, especially in *O cincta* and *O virgo,* are arranged in three such tufts The grouping into tufts is less marked on the dorsal side The longest hairs are in the middle of each tuft, and all together form the apex of the cone, whereas the short and intermediate hairs give increased circumference to the base and body of the cone

These hairs vary in length from a small fraction of a millimeter to a maximum of 1 6 mm The proximal end of the shaft of a hair is comparatively stout, but tapers gracefully toward the distal end This end also has a distinct curve with the concave side facing the orifice Each hair is firmly attached at the base, but the shaft is flexible enough to assume the shape of the surface of the water or

to curve about the terminal bubbles of gas Plumules occur along either side of the shaft from a position near the place of attachment to the extreme tip Those near the base are short, but they gradually increase to a maximum length which is maintained almost to the tip The length of the plumules is about equal on both sides of a shaft The maximum length recorded was 92 microns

Plumules arise on the somewhat flat side of each hair and diverge from both sides of the shaft Those on one side are directly opposite those on the other The angle of diversion is about 40 to 45 degrees while the hairs are spread out on the surface of the water and much more acute when the larvae are submerged and are inclosing a bubble of gas When the hairs are spread, the plumules generally touch the plumules of adjacent hairs on either side This is true throughout the length of the short hairs, but does not apply to the distal portions of the long ones On the lateral side of the corona the plumules of the small hairs actually overlap Under natural conditions the surface of the hairs which face toward the orifice is hydrofuge This property is lost as conditions change

The shaft of each hair is hollow (Fig 20), open at the proximal end, and closed at the distal end Near the proximal end the cavity is somewhat reduced in diameter, but terminates in a bulb-shaped space The bulb maintains a connection with the haemocoele by a small opening in the base of the hair and by a canal through the body wall Roughly, a transverse section of a hair is semicircular, especially the cavity This cavity varies in shape and size in different regions of a hair, being smallest at either end and largest in the middle The largest cavities of those measured showed a variation of 7–12 microns along the greatest diameter As nearly as could be determined from histological preparations, this tubular cavity is filled with a fluid devoid of cells It gives a zonal appearance as shown in Figure 20 It is not granular, but takes stain in such a manner as to give the appearance of several zones of material differing in consistency This substance remains in sections fractured in cutting as well as in perfect sections In fact, sections that were broken into two distinct parts retained the substance in each part

The wall of the hair is comparatively heavy The flat side which bears the plumules is the thicker It consists of a layer of epidermis, a layer of dermis, and apparently a very thin layer of hypodermis, although the cells were not distinguishable The epidermis is rather

even in thickness on the rounded side, but swollen in the middle of the flat side It is also continuous with the plumules, extending off at angles from either side of this swelling At the point where the epidermis thickens it replaces the underlying dermis in proportion to the amount of swelling In addition to the extension of epidermis to produce plumules on the sides it is also projected on the rounded surface in the form of spines, hooks, and ridges Serial sections indicate that they occur in a haphazard order The spines and ridges are stout, and rather sharp, and are most frequent at a position (Fig 20 *spi*) directly opposite the flat side They may be present singly or in pairs When single, the spine or ridge is in the middle of the semicircle, and when in pairs they are rather close to each other on either side of the mid-line Symmetry of arrangement is pronounced The hooks are less abundant and occur on the lateral sides of the hair

Together, all the plumose hairs of a larva form the corona, a funnel-shaped structure when spread on the surface of the water and a cone- or bulb-shaped structure when submerged At the bottom of this funnel or cone is the orifice (Fig 23 *ro*) through which the air passes into the respiratory chamber The function of these hairs will be discussed in the section on respiration

Orifice to respiratory chamber

The orifice to the respiratory chamber (Fig 23 *ro*) extends across the entire width of the abdomen, having hinged articulation in both right and left lateral edges It is bounded by two heavy, bladelike bars, which form the dorsal and ventral terminations of the body wall These blades are rather narrow, rigid, slightly beveled, generally smooth, crescent-shaped, and fit together when closed, producing a very effective seal Ridges occur at the line of attachment to the body wall The dorsal blade fits under the ventral one, the two overlapping each other like blades of scissors When the orifice is closed, the beveled surfaces fit each other and the ridges mesh neatly

These blades (Fig 22 *bl*) consist of an exceptionally thick layer of cuticle and a thin layer of hypodermis In some specimens a series of rounded projections were observed on the smooth surface of the mid-section of these blades They had the appearance of small tubercles, and were arranged in series of three or four, parallel

to the curvature of the blades So far as could be determined, these tubercles were a detriment rather than an asset to this otherwise efficient closing device

Membrane of respiratory chamber

The respiratory chamber (Figs 5, 24 *rc*) is a thin, membranous sac situated in the caudal end of the last abdominal somite When inflated with gas this sac is slightly compressed dorso-ventrally and occupies most of the body cavity of that region The blades form the periphery of the orifice and determine the size of the aperture Two posterior spiracles are at the dorso-cranial end of the chamber, on the right and left sides The membrane is attached to the rims of these spiracles, which are separated by a somewhat vertical strip of membrane with two small pouches directed forward Muscles are attached to the ends of these pouches On the floor of the chamber and ventrad to the spiracles are the openings into two large pouches These pouches (Fig 24 *lp*) appear to be evaginations of the chamber and lie against the ventral wall of the body, extending craniad to a position parallel to the mid-point of the anal slit Each is connected with the chamber by a short neck which widens to form the flat, wrinkled pouches that occupy almost the entire width of the ventral side of the haemocoele They were always partly deflated when exposed by dissection, but were readily inflated experimentally The membrane of the large pouches is somewhat thinner and more delicate in structure than the main chamber, although it is continuous with it At the time of ecdysis the respiratory chamber and accessories remain in the larval skin The chamber membrane is inflated to capacity and quite firm, but the large pouches are partly deflated and wrinkled The orifice and the spiracles are the only real openings in this chamber

POSTERIOR SPIRACLES

The two main spiracles (Figs 2, 5, 24 *ps*), located in the respiratory chamber, are the gateways to the tracheal system A pair of these spiracles in *O cincta* were 175 microns long and 140 microns wide Viewed from the side, a spiracle resembles a truncated cone, with the base facing the respiratory chamber and the long side dorsad They are intricate structures of firm, chitinous rings with radiating and parallel tubes, supported by membrane Under pres-

sure they break rather than bend, but are not especially delicate for such small objects The reaction to stain indicates that the rings and tubes are cuticular in nature

The frame of a spiracle (Figs 10, 11) consists of a heavy chitinous ring (r_1) into which a lighter ring (r_2) fits perfectly This heavy ring faces the respiratory chamber The first ring supports an earlike structure (Fig 11 *e*) on the lateral margin, and a row of short, stout tubes which radiate to the central membrane The earlike flap on the lateral margin is semirigid and forms part of the wall of the respiratory chamber These erect flaps are slightly concave and often turn over along the distal margin The surface facing the spiracle is thickly studded with coarse, slightly curved, hollow spines, which are closed at the tips and directed toward the spiracle Some of these flaps lean slightly over the spiracles, but never have they been observed as a lid or cover of the spiracles The median and ventral parts of the heavy ring are the thickest and support the stoutest tubes Transverse sections through the spiracle show that this ring has a sector of chitin around the thickest part Short, hollow tubes (tu_1) radiate from the ring to the central membrane, which occupies an irregular area inclosed by the ring Although these tubes are not uniform in diameter, length, and intervals on the ring, they do intergrade uniformly The base of each tube flares and is continuous with the ring, whereas the distal end flares and is continuous with the central membrane At the base of many of the larger tubes are three small holes arranged in the form of a triangle

The second ring (Fig 10) consists of a lighter and somewhat smaller rim which gradually disappears on the dorsal side in the formation of a membranous lip (*l*) Radiating from the inner margin of this ring are tubes (tu_2) of various lengths and diameters which terminate in the central membrane (*cm*) These tubes are arranged in two irregular zigzag rows The tubes (tu_3) from the lip to the central membrane do not seem to have a definite arrangement All the tubes are hollow and flare at the ends Those terminating in the membrane often have circular openings In addition to the tubes attached at both ends there are hollow spines on the membrane that are free and apparently closed at the distal end

In dehydrated and stained specimens the central membrane is wrinkled and firm Sections show that it is thin and more than ample in area for the space which it occupies It has never been observed

to be stretched like a drumhead and probably is soft and flexible in the living larva

The dorsal lip is really a diffused section of the light ring (r_2) The longest tubes in the spiracle are attached to it on the inside, and the tracheal trunk is attached on the cranial margin There are no taenidia in the lip, which makes it possible to distinguish the place where the tracheal trunk is attached

The two parts of the spiracle just described do not separate readily The specimens used for Figures 10 and 11 were especially good They were obtained by seizing the ear and the lip of the spiracle with forceps and carefully pulling in opposite directions The only apparent break occurred where the short radiating tubes in the first ring separated from the central membrane It is believed that a spiracle is a single structure and not made up of two distinct parts However, it is much simpler to describe it in parts than as a single unit

TRACHEAL SYSTEM

The tracheal systems (Figs 1–4) of the *Odontomyia* and *Stratiomyia* studied have the same general plan, namely, two main trunks and two smaller lateral trunks, all of which extend throughout the length of the body and are connected with each other by transverse tracheae From the trunks tracheae lead off to the visceral organs, the ganglia in the thorax, the head, and the skin and muscles of each somite

The labeling system and the terminology of Kennedy (1922), modified by Dunavan (1929), is followed wherever possible Although Dunavan (1929) and Wahl (1900) worked on species of *Eristalis*, their sketches and descriptions were followed for the purpose of comparison of structures common to these stratiomyiads Since there is considerable modification of spiracular and leg tracheae, a comparison of homologous parts has not been completed at this time Figures 1–4 were made from actual specimens and are not composite drawings of a series of specimens Until a great many specimens can be studied the homology of the lesser tracheal tubes cannot be definitely established The variation in the number of tracheae leading to the ganglia in the thorax, as well as the variation in the origin of the tracheae, is very pronounced These variations will be mentioned when the structures are described

Dorsal aspect

Specimens of *O cincta* and *S discalis* in the last larval instar were relaxed with concentrated chlorotone and submerged in pure glycerine to prevent the escape of gas from the tracheal system The skin was punctured to admit glycerine into the haemocoele After six to twelve hours the entire dorsum was removed from the larva Tracheae appeared silver-white against the glycerine background, and minute as well as gross structures were readily observed with a binocular microscope

Main trunks

The main trunks (Figs 2, 4, 5 *mt*) are attached to the posterior spiracles The line of attachment follows the ventral rim and dorsal lip of the cephalic face of the spiracle From the spiracles the trunks gradually increase in size through the abdomen and become greatly reduced in the thorax, where they terminate in the anterior spiracles and in branches to the head and pharynx In *O cincta* these trunks maintain a rather uniform diameter from the beginning of the seventh abdominal somite craniad to the first abdominal somite In either the first abdominal or the metathoracic somite the trunks taper very abruptly and continue craniad to the spiracles as much reduced tubes In *S discalis* and *S norma* the abrupt decrease in size of the main trunks occurs in the mesothoracic somite, and is more pronounced than in *O cincta* The trunks are also more slender in the sixth and seventh abdominal somites than in *O cincta* These trunks vary in shape with the degree of inflation When inflated to the maximum, they approach a circular outline in transverse section, but are usually oval or flat when dissected One inflated main trunk in *O cincta* was one millimeter in diameter These main trunks have taenidia which uncoil as a single thread

It is interesting to note here that, although the general plan of this tracheal system is similar to that of *Eristalis*, the trunks are in no way convoluted to accommodate for the contraction and extension of the body The larvae of these stratiomyiads do not contract to the same degree as *Eristalis*, nevertheless, the trunks must be very elastic to accommodate for the change in body length without convoluting This is especially true for *S discalis* and *S norma*

Dorsal connectives

Ten dorsal connectives extend from one main trunk to the other (Figs 2, 4, 1–10) These occur at regular intervals between the mesothoracic and seventh abdominal somites They arise in the median side of the main trunks and form dorsal loops bearing small tracheae The capacity of these connectives is more than ample for the slender branches which emanate from them to the dorsal muscles, and might serve as viaducts for the exchange of gas from one main trunk to the other The loop which each forms allows for the contraction and extension of the larva in locomotion as well as for maximum inflation of the tracheal trunks Usually, four small forked branches arise at the top of each loop, two of which extend somewhat craniad and two caudad The number and position of these branches are variable They may have separate attachments, or two common attachments There are from three to six branches from each dorsal connective The first dorsal connective gives rise to extensive tracheae leading to the pharyngeal region and head capsule as well as to the dorsal muscles

Lateral trunks

Laterad and more or less parallel to each main trunk is a long, slender tracheal tube called a lateral trunk (Figs 2, 4 *lt*) These two trunks are attached to the main trunks anteriorly, near the anterior spiracles, and posteriorly in the last abdominal somite In addition to the end attachments there are eight other tubes connecting each lateral trunk with its adjacent main trunk The lateral trunks do not maintain uniformity of size throughout their length, being greatest in diameter in the same region where the main trunks are largest

According to Dunavan (1929), the tracheal tubes connecting the lateral and main trunks in *Eristalis* are spiracular trunks (Figs 1, 3 *a*) This is probably a very excellent descriptive name, since eight of the ten pairs of spiracular trunks are connected by small tubes to lateral spiracles In the case of *E tenax* L and *E arbustorum* the first and tenth trunks do not end in spiracles The eleventh pair of spiracles is located at the posterior end of the main trunks, as in the stratiomyiads discussed in this work

There is no uniformity with respect to the position and number

per somite of small tracheae from the lateral trunks to the dorsal and ventral muscles Since these larvae have no legs the tracheae which would otherwise supply them are not needed for that purpose Whether that accounts for the great irregularity has not been determined The tergal tracheae (Fig 2 *t*) which supply the dorso-lateral muscles usually arise at the distal ends of the spiracular trunks A tergal trachea may be missing, and again it may come off from the lateral trunk near its junction with the spiracular trunk The sternal tracheae (Fig 2 *s*) to the ventro-lateral muscles usually arise on the lateral trunks caudad to the junctions to the spiracular trunks The tergal and sternal tracheae branch and rebranch, forming numerous tracheal tubes to the muscles and the integument Other tracheae, similar in size, arise from the lateral trunks and possibly are homologous with the leg tracheae in the larvae of other species The ganglionic and visceral tracheae will be discussed together with the tracheae observed in the ventral aspect of the system

Lateral spiracles

Swammerdam and Miall (1895) claim that "*Stratiomys*" possesses nine pairs of lateral spiracles According to Miall, "branches from the longitudinal air-tubes pass to them on the inside" Hart (1895), writing about *O cincta*, states that there are "spiracles on the upper side of the lateral margins of segments 1 and 4 10" Irwin-Smith (1923), working on larvae of terrestrial stratiomyiads in Australia, found lateral spiracles It happens that the species of *Odontomyia* and *Stratiomyia* studied by the author have only two pairs of spiracles which are connected on the inside with tracheae, namely, the pair of lateral spiracles on the prothoracic somite and the inclosed pair in the last abdominal somite

There are structures on the external surface of the integument which superficially resemble spiracles, but careful dissections in glycerine reveal neither tracheal tubes nor cords attached to them on the inside To be absolutely sure that small tubes were not overlooked, serial sections were made of each somite in question

The tissue was double embedded (celloidin followed by paraffin) and sectioned ten microns thick Delafield's haematoxylin and eosin were used as stains Excellent serial sections showed structures in normal position, such as tracheae, Malpighian tubes, muscle attachments, and setae with channels through the cuticle, but no spiracles

with inside connections The brownish spot in the position of a spiracle is apparently an external indication of a muscle attachment

Although Irwin-Smith did not make serial sections of *Metaponia rubriceps* Macquart, she concludes that lateral spiracles are present on all somites except the mesothorax There is no evidence that either Miall or Hart made histological study of their material It is quite apparent that the presence of lateral spiracles on the abdominal somites is not a family character, since some species possess them and others do not In all probability aquatic larvae would be less likely to have lateral spiracles than would the terrestrial ones Theoretically they might be regarded as lost structures, since the tendency of the primitive insects is to have eleven pairs of spiracles However, it seems quite logical to agree with Dunavan that the tubes connecting the main and lateral trunks should be called spiracular connections

Anterior spiracles

The anterior spiracles (Fig 6 *as*) are located in the middle region of the dorso-lateral margin of the prothorax Externally these spiracles are slightly oval, are composed of hyaline chitin, are somewhat elevated in the center, and have suppressed margins The stigma is guarded by a short papilla with diameter equal to that of the stigma These spiracles face dorsally, but beneath the integument they are directed caudad to meet the prothoracic spiracular trunks to which they are connected Because of this bend it is impossible to get a sagittal section through the stigma, stigmatic chamber, and trachea at the same time However, Figures 7–9 give some idea of the relative length and shape of these structures

The stigmatic aperture (*sa*) is in the center of a cone-shaped eminence of heavy cuticle which covers the stigmatic chamber (*sc*) The stigmatic chamber corresponds to the "felted chamber" (*Filzkammer*) described by Meijere (1895) It is plugged for a considerable distance by a mesh of chitinous tubes (*tu*) which vary in size, the largest ones being near the stigmatic aperture and the smallest where the chamber joins the spiracular trunk Although Figures 7–9 were not made from the same spiracle, they represent a typical series of sections through the stigma and chamber

Near the stigma the largest chitinous tubes radiate from a definite point of attachment to the wall of the chamber Figure 8 indicates that at least some tubes are open to the vestibule below the

stigmatic aperture These tubes may extend entirely across the chamber and be attached wherever they touch its wall In many instances it was possible to see that these tubes were open at the point of attachment In one case in particular tubes radiated fanwise from a central tube These tubes gradually decrease in size and increase in number, then suddenly cease to occur They form a very intricate filter between the atmospheric air and the tracheal trunk

Between the "felted" portion of the chamber and the taenidium-bearing trachea there is an irregular chamber with a constricted zone near the end Its wall is thin, apparently soft and flexible A thick layer of hypodermal cells (*hy*) surrounds the spiracular chamber and this thin-walled chamber connecting it to the main trunk

Ventral aspect

A description of the ventral aspect of the tracheal systems of *S norma* and *O cincta* (Figs 1, 3) will not include that of structures common to both dorsal and ventral aspects which have already been described, such as the lateral and spiracular trunks and the tergal and sternal branches The principal ventral tracheae consist of (1) branches to the visceral organs, (2) tracheae to the main ganglia, and (3) the anterior commissure

Visceral tracheae

The main visceral trachea (*b*) of a somite usually arises at the base of a spiracular trunk, but occasionally originates on some other part of it Generally there are a pair of visceral tracheae in the metathoracic somite and a pair in each of the first seven abdominal somites However, this may not always be the case, as is shown in Figures 1 and 3 Other variations were observed, but sufficient specimens have not been examined to determine the typical formula for these tracheae

The minor branches (*c*) arise either at the same point as do the main visceral tracheae or directly from the main trachea slightly distad from its point of origin These visceral tracheae have many branches and extensive ramifications

Ganglionic tracheae

The ganglionic tracheae (Figs 1, 3, 6 *g*) arise in the lateral trunks and end in the ganglia which are situated in the mesothoracic and

metathoracic somites There are twelve ganglia, all but the first of which are supplied with tracheae Each thoracic somite has a ganglionic trachea which gives off a pair of accessory tracheae to the second, third, and fourth ganglia These tracheae (Fig 6 *ag*) are slightly separated at their origin and end in a number of short tubes on either side of the ganglia It should also be mentioned here that the ganglionic trachea in the prothorax gives rise to a pair of tracheal tubes leading along the pharynx

The distribution of the ganglionic tracheae in the abdomen is puzzling In *O cincta*, tracheae to the ganglia occur in all but the eighth abdominal somite, in *S lativentris*, in all but the seventh and eighth somites *S discalis* and *S norma* seem to agree with *S lativentris* in this respect Usually one trachea per somite is produced in the abdominal region When a pair of ganglionic tracheae are present in the abdomen they generally occur in the first somite In *O cincta* (Tables II and III) the variation in number is 5–8, in *S lativentris*, 4–7 These tracheae do not seem to comply with any formula with regard to their occurrence All may arise on one side or they may occur on both sides in many combinations

Two facts, however, are apparent, namely (1) that the tracheae join in the order of origin in the abdominal somites, and (2) that those which arise on the left side join the left side of the ganglia and vice versa, they have never been observed to cross from one side to the other In *O cincta* the usual number of unpaired tracheae is 7 and in *S lativentris*, 6 Specimen 3 (Table II) showed the only example of a pair of tracheae in which the components united, in the sixth abdominal somite, to form a single tube leading to a ganglion

The main tracheal trunks extend craniad from the base of the first spiracular trunks, decreasing abruptly in size as they branch There are six pairs of branches leading to the head, atrium, and pharynx, several of which are long, the rest are rather short and blunt One pair of the head tracheae gives rise to tubes which terminate on the lateral sides of the first ganglion, these tubes should be regarded as ganglionic tracheae similar to those already described They are not united, nevertheless, they represent the first pair of ganglionic tracheae and will here be called the cephalo-prothoracic ganglionic tracheae (Fig 6 *cps*)

TABLE II

TRACHEAE LEADING FROM THE LATERAL TRUNKS TO THE GANGLIA IN THE LARVAE OF *ODONTOMYIA CINCTA* OLIV

Cephalo-prothoracic ganglionic tracheae are not included in this table

Number of specimen		1		2		3		4		5		6		7		8		9		10		11	
R (= right) L (= left)		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
Thorax	I	+* –†	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
	II	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
	III	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
Abdomen	I	+	+	+			+	+		+					+	+	+	+		+	+		+
	II	+		+			+	+			+		+	+			+	+			+		+
	III	+		+			+	+		+		+		+			+					+	
	IV		+	+			+	+		+					+	+		+	+	+			
	V	+		+			+	+		+		+		+			+	+		+			
	VI	+		+		+ Fused	+		+		+	+			+				+	+		+	
	VII		+	+		+			+	+			+		+		+			+			?
	VIII																						
Total		8 + 6 = 14		10 + 3 = 13		5 + 9 = 14		8 + 5 = 13		8 + 5 = 13		6 + 5 = 11		6 + 7 = 13		5 + 8 = 13		7 + 5 = 12		8 + 5 = 13		5 + 5 = 10?	

* + = Trachea present. Perfect dissection in all but number 11 † – = Tube connecting left and right tracheae

TABLE III

RACHEAE LEADING FROM THE LATERAL TRUNKS TO THE GANGLIA IN THE LARVAE OF *STRATIOMYIA LATIVENTRIS* LW

Cephalo-prothoracic ganglionic tracheae are not included in this table

Number of specimen		1		2		3		4		5		6		7		8		9	
R (= right) L (= left)		R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L
Thorax	I	+* –†	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
	II	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
	III	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+	+ –	+
Abdomen	I	+	+?	+?	+	+	+	+?	+	+		+			+	+		+	
	II		+		+		+		+	+		+		+			+	+	
	III		+	+			+		+	+		+			+		+	+	
	IV		+	?	?		+		+?	+		+				+			+
	V	+		*	?	+		+			+		+	+			+		+
	VI		+		+		+	+			+		+				+	+	
	VII																		
	VIII																		
Total		5 + 7* = 12?				5 + 8 = 13		5? + 6 = 11 + 2?		⁻ + 5 = 12		7 + 5 = 12		5 + 5 = 10		5 + 7 = 12		7 + 5 = 12	
				Tissue injured in dissection		Excellent specimen		Perfect example of no VI on right		Perfect dissection		Perfect dissection		Good dissection		Poor specimen		Perfect specimen, perfect dissection	

* + = Tracheae present † – = Tube connecting left and right tracheae

Anterior commissure and tubes to imaginal disks

Along the ventral side of the anterior end of the main trunks two or three pairs of short, branched tracheae (Fig 6 d_1) lead to a pair of imaginal disks located caudad to the pharynx From the median side of the main trunk, opposite the base of the first spiracular trunk, there is the second pair of tracheae (d_2) leading to imaginal disks The anterior commissure (*ac*), a large, looplike tube connecting the main trunks, has its origin directly caudad from this pair of tracheae Near the middle of the loop, but slightly separated, are two short tracheae (d_3), which lead to the third pair of imaginal disks craniad to the ganglia

Function of the Respiratory System

RESPIRATORY CHAMBER

From the description and figures of the respiratory systems of certain *Odontomyia* and *Stratiomyia* larvae it is apparent that they breathe free air The various parts of the respiratory system as well as the integument will be discussed in relation to respiration Since the system has been described from the posterior end forward, the function of the parts of the system will be discussed in the same order

Function of plumose hairs

The corona of plumose hairs surrounding the respiratory orifice is accessory to respiration rather than functioning, especially in the exchange of gases It is possible that these hairs serve in a way similar to that of the integument, since they are hollow and are connected with the haemocoele Mature larvae live and pupate, and adults emerge after the removal of plumose hairs, plainly showing that their primary function is not respiratory

It has already been mentioned that these hairs are hydrofuge on the surface facing the orifice and that they spread funnel-like on the surface of the water while the rest of the larva is submerged In this position the corona of hairs prevents water from entering the respiratory chamber and allows a free passage of gas to and from the respiratory system

In addition to this important function in surface breathing these hairs are of great use to the larva when it is completely submerged As a larva sinks the corona folds up, with the tips of the hairs coming

together to form a cone filled with atmospheric air This store of air rests on the respiratory orifice and is available for respiration As it is drawn into the respiratory chamber the cone collapses, and as gas is expelled from the tracheal trunks the cone forms again

The mechanism for opening and closing the corona is not primarily muscular As the orifice closes the hairs are brought nearer together at the apex of the funnel, but the corona will not fold up under this condition, when the larva is at the surface, nor will it open when the larva is submerged The change in shape from a cone to a funnel is due to the flexibility of the shaft of each plumose hair This was demonstrated in the following manner The last somite, bearing a full complement of hairs, was clipped from an empty larval skin which had been dry for more than a year, and was thoroughly wet in distilled water This structure floated on the surface even after it had been completely soaked The dry hairs, which were matted together, gradually unfolded and formed a perfect corona When this somite was forced below the surface, the corona folded up in normal fashion, taking a bubble of air down with it When the somite was released, it came to the surface and the hairs spread out in the same manner as in living larvae This was repeated a great number of times until the hydrofuge property of the hairs had been destroyed With the loss of this property the hairs ceased to carry a bubble of air or to spread out on the water's surface

The proportionate length of the hairs varies with the size and age of larvae of the same species Mature larvae have shorter plumose hairs than do immature larvae It seems that young larvae are much more dependent upon the hairs to maintain them at the surface of the water than are mature larvae It is a well-known fact that these larvae drop to the bottom and rise again at will In order that the larva may rise, gas is liberated from the respiratory system and held as a bubble by the plumose hairs Eventually the bubble becomes large enough to float the larva to the surface As soon as the tips of the hairs touch the surface they spread out However, if the hairs are clipped off close to the body, especially in a young larva, the larva may hold sufficient gas in a bubble over the respiratory orifice to enable it to rise to the surface, but it drops back as soon as the bubble touches the surface

Experiments were performed to test this phenomenon In one the hairs were clipped from five larvae, and five similar larvae, un-

clipped, were used as controls Test larvae and controls were placed in separate glass-stoppered bottles one third full of distilled water To begin the experiment the bottles were shaken, and all larvae were submerged In twenty minutes all the controls were either swimming on the surface of the water or crawling on the side of the bottle above the water line The clipped larvae produced bubbles and one by one floated to the top only to have their bubbles explode, with the result that they dropped back to the bottom It required twenty minutes for the slowest one to reach the top for the first time Forty-five minutes after the experiment started one larva had repeated the trip to the surface One hour after the beginning of the experiment a larva rose to the surface, lost its bubble of gas, and dropped back for the third time It required twenty-five seconds for one of these larvae to float from the bottom of the container to the surface and three seconds to drop back the same distance Test larvae repeated this phenomenon until they became exhausted, but the controls left the water and returned to it at will This experiment was continued from April 11 to May 23 before all test larvae and controls were dead at the bottom of their bottles They were without food through the experiment

It is quite apparent that small larvae from which the plumose hairs have been removed cannot come to the surface and remain there Mature larvae are not always affected in this way by the loss of the corona The specific gravity of the larger ones seems to be just a little less, probably owing to the store of fat and oil or the large tracheal trunks filled with gas, or both The plumose hairs of two large larvae of *O cincta* were clipped July 28 and the larvae were still alive in the laboratory the following February 18

Function of orifice

In the section on the morphology of the respiratory orifice it was made clear that the two chitinous blades forming the boundary of the orifice fit together perfectly when closed When it is open, there is free passage of gas in and out of the respiratory system In addition to closing the system to the passage of gas the orifice also prevents the entrance of water and other foreign matter The surface of the blades is hydrofuge, as are the plumose hairs, and, in the absence of the hairs, does not allow water to creep over it into the respiratory chamber This was demonstrated by clipping the hairs and submerg-

ing the larva by force Very often a small bubble of air was held by the rim of the orifice

The mechanism for opening and closing the orifice consists of a series of muscles inclosed in the last abdominal somite These muscles work in conjunction with the respiratory chamber and will be discussed in detail along with the function of that organ

Function of chamber

Gas passing through the orifice comes directly into the respiratory chamber, which serves as a passageway to the tracheal trunks and as a reservoir for respiratory gases Since it is thin-walled and is supplied with muscles extending to various points on the inner surface of the integument, it is readily inflated and deflated The semi-diagrammatic Figures 12–19 and 24 and the following description of the muscles will give some idea of how the respiratory chamber functions

The first muscles, beginning with the posterior tip of the abdomen, arise from the ventral body wall, on either side of the anal groove, and extend obliquely toward the median line of the ventral wall of the respiratory chamber These muscles (*v ms*) have a bifid insertion on the chamber and maintain this relative position caudad to the region of the posterior spiracles In general, they are short, rather wide, and extremely thick Their contraction tends to inflate the chamber

A dorsal pair of oblique muscles (*d ms*) is similarly situated The muscles are much shorter and narrower, and have the same action, probably contracting simultaneously to fill the chamber with gas

Caudad to the spiracles a muscle extends across the haemocoele between the ventral body wall and the respiratory chamber It is a straight muscle (*tr ms*) with a median attachment to the inner surface of the anal groove and lateral attachments on both the right and left ventro-lateral surfaces of the body wall It intercepts the ventral oblique muscles and passes through them Contraction of this muscle compresses the body ventro-laterally and partly opposes the muscles already mentioned

A parallel pair of dorso-ventral muscles (*l ms*) extend across the lateral angles of the haemocoele They are narrow but sturdy, and reach from the tip of the abdomen craniad to a point well in front of the spiracles Their contraction compresses the body dorso-ventrally and closes the respiratory chamber

There are at least three pairs of small muscles (*ob ms*), two of which extend from the dorso-lateral wall of the body to the dorso-lateral wall of the respiratory chamber One pair in the region of the spiracles arise in the ventro-lateral wall of the body and are attached to the extreme lateral rim of the chamber These muscles are very small From their position it is apparent that they aid the dorsal and ventral muscles to inflate the respiratory chamber

Another pair of important muscles (*bi ms*) arise at the tips of the small pouches in the cranial end of the chamber Near their origin they bifurcate, with one half of each extending dorso-craniad to the roof of the haemocoele and the other half to the floor on either side of the anus Contraction of these muscles compresses the chamber, pulls it forward, and aids in closing the orifice The dorsal and ventral muscles work in opposition to these and pull the chamber back and allow the orifice to open

Near the dorso-median rim of each spiracle there is a slender muscle (*lo ms*) which extends craniad to the dorsal body wall In transverse section it appears like a longitudinal muscle, but it does not extend to the seventh somite for attachment These muscles help to pull the chamber forward and act in conjunction with the muscles just mentioned

Action of these muscles draws atmospheric air into the chamber and expels gas from it Whatever part other muscles, not mentioned, may play in the inflation and deflation of the chamber, those described are the most important It is believed that the process of external respiration is controlled in the region of the respiratory chamber When the chamber is completely deflated, the inner dorsal and ventral surfaces rest against each other perfectly (Figs 16–19), and the orifice is closed The closing of the orifice, with the complete collapse of the chamber, forms a perfect seal for the gas inclosed in the tracheal system and prevents water from entering

It is an easily demonstrated fact that larvae such as those used in this work liberate gas from the respiratory system while completely under water This occurs when they are submerged by unnatural causes or by their own volition A larva that is forcibly submerged carries a bubble of air with it The bubble may be drawn completely into the tracheal system, or it may be enlarged by gas from the system and serve as a buoying agent to raise the insect to the surface again.

If a larva is robbed of its bubble of reserve air immediately after

it is forced down, it will eventually liberate gas to replace the air removed Gas bubbles have been taken repeatedly from individuals without allowing them opportunity to replenish the supply from the atmosphere There is, however, no regularity in the production of the bubbles It varies under constant conditions, indicating that the larva controls this phenomenon

Experiments were conducted with *O cincta* and *O virgo* to determine whether pressure applied to the body would force gas from the system Pressure was exerted by placing the forefinger on the anterior end of a submerged larva and massaging toward the posterior end in an attempt to force gas from the tracheae through the spiracles and the respiratory chamber Repetition of this act usually resulted in the yielding of gas, although the amount and regularity varied Some larvae would not release any gas, some would release small quantities at irregular intervals, and others seemed to become fatigued under continued pressure and suddenly released large quantities of gas Larvae that would not release gas when massaged were treated in the following manner The tip of the abdomen was compressed laterally with forceps in order to cause the orifice to open The point of a fine insect pin was inserted through the orifice and the compression relaxed This pin in no way injured the larva, but kept the orifice slightly open while pressure was being applied In some gas was forced out and in others it was not This is proof that the orifice does not have complete control An attempt to relax larvae by injecting chlorotone into the mesothorax had no effect on the controlling mechanism That the writer might be certain that the specimens used in these tests did have gas in their tracheal systems each was bisected before it was allowed to come to the surface In every one some gas still remained in the tracheae

When the part of the somite containing the chamber and muscles had been snipped off, the gas was liberated freely, showing that control is due to muscular contraction in the region of the respiratory chamber Prying the orifice open and compressing the chamber helped to counteract the action of the muscles to some extent Under continued pressure and massaging these muscles relax, presumably to accommodate for the general discomfort of the larva

The large pouches arising from the floor of the cranial end of the chamber are accessory gas sacs They are continuous with the chamber and serve as extra storage space for respiratory gases during

extended periods of submergence Experimentally they can be inflated and deflated along with the respiratory chamber Since they are of softer membrane they collapse before the chamber does

Function of the posterior spiracles

There can be no doubt that the spiracles in the cranial end of the respiratory chamber are the gates through which respiratory gases pass to and from the tracheal system From their position it is obvious that gas must pass through them, but it was necessary to demonstrate how and through what part of the spiracle it goes Since the spiracles are inclosed in the body and since the integument is opaque, it is impossible to observe the functioning of the spiracles in living larvae

A technic was developed for the purpose of forcing air through the spiracles while they were submerged, and the results were ob-

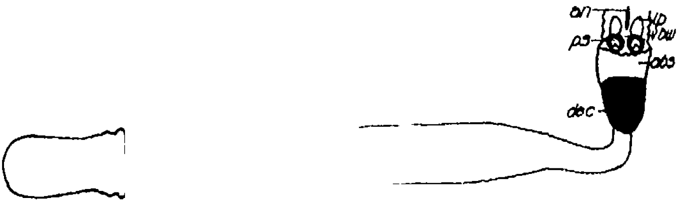

FIG 21 Diagram of pipette, together with part of the last abdominal somite showing the posterior spiracles exposed Explanation of abbreviations *abs*, last abdominal somite, *an* anus, *de c*, De Khotinsky cement, *lp*, large air pouch, *ps*, posterior spiracle, *v bw*, ventral body wall

served with a binocular microscope Other equipment, in addition to De Khotinsky cement and a dish of water, consisted of an ordinary pipette with the tip drawn into a capillary just small enough to be inserted through the orifice into the respiratory chamber

The head and thorax of mature *O cincta* larvae were suddenly dipped into boiling water for the purpose of killing them Care was taken not to allow the last abdominal somite to touch the hot water The capillary of the pipette was carefully prepared for insertion into the respiratory chamber A thin coat of De Khotinsky cement was applied to the region of the capillary, which was to be sealed to the larva In addition to the thin coat of cement a quantity sufficient to

complete the seal was added, so that it might be worked down the side of the capillary and completely cover the tip of the abdomen

The last somite was compressed laterally, to force the orifice open, and the capillary was inserted With hot probes and needles the cement was slowly warmed and worked over the tip until a perfect seal was effected When there were no leaks the body of the larva was clipped off anterior to the anus Pressure on the pipette bulb caused the air to pass through the spiracles and to bubble from the main trunks (See Fig 21)

The next step consisted in exposing the anterior face of the spiracles without puncturing the respiratory chamber or the accessory gas pouches A small lens knife was used under a binocular microscope Desiccation was prevented by occasionally dipping the specimen in water

Tests consisted of submerging the pipette and the attached dissection and observing with a microscope the effect of pressure on the bulb of the pipette A steady gentle pressure caused the air to pass through the spiracles and form small bubbles These bubbles emanated from the spiracles with a suddenness that made it difficult to detect the gas before the bubbles had formed or to determine the part of the spiracles through which it had passed Pressure sufficient to force the gas through caused a spurt of bubbles which stopped as suddenly as it began when pressure was released However, air could be seen along the ventral rim of the spiracle and between the chitinous rings and central membrane Slight alternate pressure and relaxation on the bulb caused the air to pulsate between the short radiating tubes which form a grating from the ring to the membrane The convincing evidence in support of the contention that this region of the spiracle functions in the passage of gas from the chamber to the trunks was apparent when a bubble was retracted through the spiracle into the chamber Sometimes a bubble would remain in position as it formed and would be drawn back into the chamber as the pressure on the bulb was reduced The bubble would diminish in size very gradually instead of suddenly, as it had formed originally The last vestige of the bubble always disappeared through the grating of tubes between the ring and the membrane

It has been demonstrated experimentally that gas passes through the ventral portion of the spiracles, and between the chitinous tubes rather than through them

FUNCTION OF TRACHEAL SYSTEM

There is no question regarding the general function of the extensive system of tracheal trunks, branches, and fine ramifications The controversial point involves that of carbon dioxide elimination in proportion to the oxygen received by the system Regardless of the part played by the skin in elimination of carbon dioxide, the experiments which follow prove that a great deal of carbon dioxide finds its way into the tracheal system

Respiratory movements

Since there is only one opening to the tracheal system through which gas can pass freely, there must be some mechanism for circulating the respiratory gases Air enters and carbon dioxide passes out through the posterior spiracles How the currents of gas move in the system is not known Gas is kept in circulation, at least in part, by pulsations of the respiratory chamber These pulsations are accompanied by the opening and closing of the respiratory aperture

One larva, about ten millimeters in length, was observed under a binocular microscope It rested with the corona spread on the surface of the water while the orifice opened and closed thirty-five or thirty-six times per minute Opening and closing movements were correlated with a dorso-ventral compression and expansion observed only in the region of the respiratory chamber The rest of the body may, and probably does, contract and expand, thus causing changes of pressure in the tracheae The rate of pulsation was slightly accelerated by increasing the temperature of the water This pulsating phenomenon is common when larvae rest at the surface, but is not a continuous process It is believed that ventilation of the tracheal system is periodic rather than continuous

Gas analysis

It has already been mentioned that *Odontomyia* and *Stratiomyia* larvae liberate from the respiratory system gas which it collects and holds as a bubble by the plumose hairs If the hairs are removed the larvae liberate gas just the same, but are unable to hold it as well The author took advantage of this habit of the larvae and collected samples of gas for microanalysis It was not possible to obtain comparable results from the same larva or from a number of larvae

because there was no way to control the intake of air or the liberation of gas Larvae may float at the surface of the water and not be breathing, or they may ventilate the system Increased temperature stimulated their physical activity and also the respiratory exchange, as well as the liberation of gas However, the same temperature did not produce the same rate of gas liberation from the same larva or from a series of larvae The results, therefore, are of only relative significance

All analyses were made with Krogh's apparatus (1908) for microanalysis of gases, and according to his general directions To facilitate reading the graduation marks the glass jacket around the graduated tube was filled with oil instead of water When larvae were placed in the lower funnel of the instrument until bubbles of gas were liberated, the apparatus was sometimes charged with acidulated water to prevent absorption of carbon dioxide

Table IV consists of selected examples of tests made under various conditions With the exception of tests 8–13 the larvae were inserted into the lower funnel of the apparatus until gas was liberated They were placed with the posterior end upward, so that the gas could be drawn into the capillary as fast as it was released The results of tests 1 and 2 are not considered conclusive because of possible loss of carbon dioxide, which dissolved during the time required to collect a sufficient amount of gas for analysis Charging the apparatus with 2 5 per cent and 5 per cent sulphuric acid was satisfactory, and the results were accurate All the larvae used in this manner were treated first with acid to remove the calcium salts in the integument

There seems to be no real correlation between the percentages of gases in the samples and the time required to obtain them, neither does there appear to be any marked ratio of carbon dioxide to oxygen in these samples Test 6 yielded the highest percentage of carbon dioxide and a very low percentage of oxygen in one-half hour There is no way of knowing how long the larva had retained the gas in its tracheal system without inhaling a fresh supply of air The highest percentages were obtained from tests 6 and 7, collected over relatively shorter periods than tests 14–16 It is interesting to note that when the tracheal trunks of larvae that were free to breathe normally were snipped, gas was liberated which, when immediately analyzed, was composed of 1 8–7 4 per cent carbon dioxide and

TABLE IV

ANALYSIS OF GAS TAKEN FROM THE TRACHEAL SYSTEM OF *ODONTOMYIA CINCTA* LARVAE

Test no.	Medium for collecting gas	Temp. during test (Cent.)	Length of bubble (mm.)	Percentage		Remarks
				CO_2	O_2	
1	Distilled H_2O	21 6–21.9	11.2	5.48	1 78	Bubble robbed from larva and analyzed immediately
2	do.	21 9–21.9	12.8	6.27	4.67	Gas from two larvae
3	Pond water	21.6–21 9	82.5	7 63	1 09	Gas from one larva in 0 5 hour
4	do.	22.2–22.7	68.8	5.93	0.70	Gas from one larva in 1 5 hours
5	do.	21 1–21.5	35.8	2.08	0.90	Gas from one larva in 1 5 hours
6	do.	23.9–24.4	80.2	39.80	0 75	Gas from one larva in 0 5 hour
7	do.	24.7–24.4	88.4	38.91	0.83	Gas from one larva in 1 0 hour
8	2.5 per cent H_2SO_4	21 9–22.2	70 4	5.24	2.97	Gas from one larva *
9	do.	22.7–23.3	72.8	4.93	3 68	Gas from one larva *
10	do.	24.4–24.1	63 8	3.13		Gas from one larva *
11	do.	21 1–21 4	86.5	4.07		Gas from one larva *
12	do.	22.2–22.2	69 7	7 46		Gas from one larva *
13	do.	21 1–21 1	54.7	1.83	0 55	Gas from one larva *
14	5.0 per cent H_2SO_4	25.8–25.5	84.5	16.69	1 12	Gas from one larva in 4 hours
15	do.	27 7–26.9	75.8	23.75	4.29	Gas from one larva in 6.5 hours
16	do.	23.0–22.7	87.0	15.52	1.39	Gas from one larva in 21.5 hours

Determinations and calculations, including temperature corrections, were made according to Krogh's method (1908).

* Snipped with scissors and analysed immediately

3 6–0 5 per cent oxygen The maximum oxygen content is lower for these tests than for test 15, in which the specimen was submerged for six and one-half hours

These data show that larvae maintain in the tracheal trunks a relatively low percentage of oxygen and a high percentage of carbon dioxide They also definitely establish the fact that a large amount of carbon dioxide eliminated by the tissues is collected by the tracheal system and expelled through the posterior spiracles

FUNCTION OF THE ANTERIOR SPIRACLES

The anterior spiracles, situated dorso-laterally in the integument of the prothorax of the larva, have already been described morphologically An effort has been made to determine the extent to which the spiracles are used in respiration From structure alone it seems quite possible that air could be taken in very slowly through the stigma, pass through the "felted chamber," and then gain access to the main trunks This would be a very slow process because the chambers are small and the mass of chitinous tubes in them forms a loose wad through which the air would necessarily have to pass

Experimental results with mature larvae were not always comparable because it was not possible to know when all specimens used were in the same stage of development Larvae often pupated during the course of the experiment, and the internal structures suddenly changed, while at the same time respiratory activities varied Tests involving the closing of spiracles required relatively long periods of time because larvae with closed spiracles are able to survive a number of days on the gas held in the respiratory system

The plan of testing involved closing the respiratory orifice with De Khotinsky cement and submerging the larvae either in kerosene or xylol containing Sudan III It had previously been discovered that these oils stained with Sudan III entered the spiracles of young larvae and in a few hours displaced most of the gas in the tracheae Since it passed through the spiracles of young larvae in a comparatively short time, it was supposed that it would enter the anterior spiracles of mature larvae if they were open and if sufficient time was allowed

Larvae were thoroughly dried on blotting paper before the De Khotinsky cement was applied to the tip of the abdomen. The surface of the cement was softened little by little with the point of a

hot needle until the orifice was completely closed This operation did not seem to harm the larvae and did produce a seal that was tight and not affected appreciably by kerosene or xylol

The oils irritated the larvae and caused them to squirm and writhe vigorously Their activity was watched with a binocular microscope to observe whether there was any release of gas from the anterior spiracles Activity gradually ceased, and the larvae appeared dead Those in kerosene were dissected and thoroughly examined 5 7 days after the test began All the larvae were alive, but not a trace of Sudan III was found in the tracheal system These larvae had been kept at ordinary room temperature throughout the experiment

Larvae in xylol and Sudan III were slowly warmed to a temperature of 45–50 degrees centigrade Their discomfort increased with the temperature Again they were watched for the liberation of gas It was supposed that if the respiratory orifice was sealed perfectly, and the anterior spiracles were open, the increase in temperature would cause the gas to expand and create sufficient pressure in the tracheal system to force the gas out through the anterior spiracles At a temperature of approximately 50 degrees centigrade general activity ceased in 1 5 hours without liberation of gas from any part of the larvae

The specimens were allowed to cool in the stained xylol for 50 minutes, during which time the temperature dropped to about 15 degrees and then gradually returned to room temperature, where it remained 4 5 hours Two larvae were held in boiling water so that only the anterior half was submerged The heat did not force gas out through the anterior spiracles of either, but when they were dropped on the boiling water gas was forced out of the posterior end Bubbles were formed in the cement, which was softened by the hot water, indicating that the gas did not escape until the cement had melted The melting took place so quickly that it was difficult to determine whether or not the cement had softened before any gas was liberated In one case, at least, gas came through the soft cement and not between the cement and the integument

Only one larva used in this severe test contained a trace of stained xylol This slight amount of stain was found in the tracheas of the posterior end and most probably was due to a leak in the cement seal The pressure tests seem to yield quite conclusive evidence that gas does not pass from the tracheal trunks out through the anterior spiracles of mature *O cincta* larvae Nor does kerosene pass in from

the outside From the results of these experiments it seems fair to conclude that the anterior spiracles function very little, if at all, in the passage of respiratory gases

RESPIRATION OF SUBMERGED LARVAE

Since these larvae are amphibious in their habits and spend considerable time beneath the surface of the water, they serve as excellent subjects for experiments in submergence Preliminary tests consisted in placing single larvae in small stender dishes filled with water and submerging the dishes in a glass container An equal number of controls were allowed to float on the surface of the water After two days' submergence, half of the larvae were dead, and the other half were so affected that pupation and emergence of imagoes did not occur Imagoes eventually emerged from two thirds of the controls

Other tests indicated that larvae live longer when submerged in large quantities of water This led the author to suspect either that they could use the dissolved oxygen in the water or that the water received something from them that made it toxic

An attempt was made to determine experimentally whether larvae were able to use dissolved oxygen and give off carbon dioxide during forced submergence A number were kept in bottles for varying periods, after which the water was tested for dissolved oxygen by the Rideal-Stewart modification of the Winkler method as given in *Standard Methods for the Examination of Water and Sewage*, by The American Public Health Association (1925) Carbon dioxide determinations consisted of titrations with N/44 potassium hydroxide in the presence of phenolphthalein as an indicator

Boiled or distilled water that had been oxygenated was used in these tests The supply of water was stored in a large carboy and siphoned into glass-stoppered bottles A homogeneous mixture of the oxygen was obtained by thoroughly shaking the carboy before taking the samples Test bottles were filled from the bottom and allowed to overflow two or three times the capacity of each bottle Control bottles were filled in the same manner and at intervals during the filling of the test bottles This precaution was taken for the purpose of detecting any change in dissolved oxygen content occurring in the water while the samples were being taken

Larvae for these tests were generally brought in from the pools

the day before they were to be used They were freed from organic matter, which usually clings to them, and dropped into 2 5 per cent hydrochloric acid to destroy small organisms and remove calcium salts in the integument After the cleaning process they were left in a large volume of warm water for about 24 hours The warmth made them physically active and stimulated evacuation of excreta

As a test bottle was filled the larvae were suddenly introduced into the neck of the bottle with slender forceps, and the stopper was inserted Sudden introduction of a larva prevented it from taking along a bubble of air As soon as each bottle was filled with water and supplied with larvae, it was submerged in a large aquarium filled with water a few degrees cooler than the water in the bottles This prevented leaking from expansion of the water in the bottles and likewise raised the solubility threshold so that the dissolved gases remained in solution From time to time control and test bottles were removed from the aquarium and the contents tested for dissolved oxygen and carbon dioxide In most instances bottles of 70 c c capacity were used for oxygen and those of 250 c c capacity for carbon dioxide determinations It was generally quite simple to pick the larvae out of the bottles before adding the chemicals Since the organic matter was considered negligible, the steps in the regular procedure previous to the introduction of $MnSO_4$ were omitted The quantity of chemicals used was reduced in the proper proportion for 70 c c samples and the dissolved oxygen determinations were computed by titrating 50 c c of the sample

The tests for dissolved free carbon dioxide were made by siphoning 100 c c of water into a Nessler tube from the test bottle Phenolphthalein indicator was followed by titration with N/44 potassium hydroxide

The data in Tables V and VI show that larvae are able to use dissolved oxygen from the water and give off carbon dioxide to it In one instance twelve larvae removed all but a trace of dissolved oxygen from 70 c c of water in 62 hours and survived This water had 3 7 c c of oxygen per liter when the larvae were put into the bottle Most of the oxygen is removed in 18 hours Records of tests in which there was any evidence of excreta were not included in the tables It was originally supposed that the change in the amount of dissolved gas of the water was due to cutaneous respiration alone Although larvae inclosed in the bottles did produce

TABLE V

DISSOLVED OXYGEN USED BY SUBMERGED LARVAE OF *ODONTOMYIA CINCTA*

The capacity of each bottle was 70 c c

Bottle no	C c of dis. O_2 per liter		Time in hours	No of larvae	Temp (Cent)	Remarks
	Control	Test				
9	8 12		10		24 5-26 5	
4		7 67	10	5	do	All alive
5		7 55	10	5	do	do
2	8.03		22		do	
6		6 80	22	5	do	do
1	8 31		33 5		do	
7		6 14	33 5	5	do	do
1	5 13		12		12 8	
2	5 13		12		do	
4		4 90	12	5	do	All alive
9		4 90	12	5	do	do
10		4 90	12	5	do	do
3	5 25		24		do	
5		4.54	24	5	do	do
6		4 71	24	5	do	do
7		4 74	24	5	do	do
1	3 67		18		12 8	
2	3 64		18		do	
3		3 49	18	5	do	All alive
4		3 40	18	5	do	do
5		3.38	18	5	do	do
6		3 49	18	5	do	do
7		3 29	18	5	do	do
1	3 73		0		20–24	
2	3 73		15 5		do	
6		2 13	15 5	10	do	All alive
3	3.87		26		do	do
12		1 62	26	12	do	do
4	3 73		38		do	
11		2 27	38	6	do	do
14		1 53	38	10	do	do
16		trace	62	12	do	All recovered in 12 hours

TABLE VI

CARBON DIOXIDE ELIMINATION BY SUBMERGED LARVAE OF *ODONTOMYIA CINCTA*

The capacity of each bottle was 250 c c The time of each experiment was 20 hours

Bottle no	CO_2 in parts per million		No of larvae	Temp (Cent)	Remarks
	Control	Test			
1A	4 0			22 2	
2A	3 5			do	
3A	3 5			do	
4A		17 5	7	do	All alive
5A		11 0	7	do	All very active
6A		9 0	7	do	All very active
1A	7 0			24 6–26	
2A	5 7			do	
3A	7 3			do	
4A		11 0	7	do	All alive
5A		13 7	7	do	All alive One pupa
6A		12 0	7	do	All active

small bubbles occasionally, they did not do so as readily as under natural conditions When bubbles were formed gas exchange took place at the surface of the bubbles If cutaneous respiration occurred — and there is no doubt that it did — the results are included in these data

Attempts to do qualitative analyses of respiratory gases were futile During the summers of 1930 and 1931 larvae were obtainable in such small numbers that only a few series of tests could be made simultaneously It was impossible to select larvae of exactly the same stage of development and with the same rate of gas exchange It is necessary that they be of known genetic constitution before quantitative studies of metabolic processes can be attempted This involves perfecting a technic for laboratory breeding and rearing under controlled conditions so that larvae from the same egg mass or a number of egg masses will develop uniformly Until such technic is perfected the results of quantitative studies cannot be comparable and significant This applies both to the respiration of submerged larvae and to the breathing of those in atmospheric air

CUTANEOUS RESPIRATION

Cutaneous respiration has already been mentioned in connection with respiration of submerged larvae The extent to which these larvae depend on the exchange of respiratory gases through the skin is not known Acids, alkalies, alcohol, chloroform, and other chemicals apparently have little effect on these animals unless they enter the openings to the respiratory and digestive systems The skin is quite impervious to these reagents and probably to oxygen and carbon dioxide

Some preliminary experiments on gas diffusion through an empty larval skin were performed The head and last abdominal somite were clipped from an active, mature larva, and the visceral organs and muscles removed as nearly completely as possible The empty skin was allowed to dry Small glass tubes were cemented to either end of the dry skin, and the tubes were passed through rubber stoppers The stoppers served to support the skin and tubes in a glass jacket The jacket was filled with either water or barium hydroxide, and the pressure regulated with a column of mercury A three-way stopcock was connected to the free end of one of the glass tubes and a two-way stopcock to the end of the other one Oxygen, or carbon dioxide, and mercury were admitted through the first stopcock, while the second allowed the excess gas to escape and mercury to be introduced

After the jacket had been filled and the inner surface of the skin moistened with water the system was flushed with the desired gas and the pressure balanced inside and outside the skin Mercury was introduced through the first cock and displaced the gas in the first tube almost to the skin Mercury admitted through the second cock forced the gas in the second tube back through the skin into the first tube from which it displaced most of the mercury The second cock was permanently closed and the first opened to the mercury reservoir In this way oxygen or carbon dioxide was pocketed between two columns of mercury, with the larval skin as part of the system One column of mercury was fixed in position, the other fluctuated as the volume of gas changed There was no possible escape for the inclosed gas except through the skin The position of the gas in the tube was marked, and the changes in the length of the column were recorded from time to time

In every test of this kind the volume of inclosed gas decreased, an indication that both oxygen and carbon dioxide had passed, under slight pressure, through the larval skin from the inside out The rate of diffusion was relatively constant throughout a test The time for each test varied from 23 to 50 hours In general, diffusion was more rapid at higher pressures When barium hydroxide was used in the jacket the skin was examined for deposits of barium carbonate If any was produced, it was not in sufficient quantity to be noticeable Chemicals tests for it were not made Neither was the water in the jacket tested for dissolved oxygen Although gas diffused through the integument of dead larvae under experimental conditions, there is no positive assurance that it will pass through the skin of living larvae under normal conditions The data from these experiments are inadequate to furnish conclusive evidence in favor of cutaneous respiration, but are merely suggestive

Summary

1 The data reported in this paper are the results of studies on the respiration and respiratory systems of the larvae of *Odontomyia cincta* Oliv , *O virgo* Wied , *Stratiomyia discalis* Lw , *S norma* Wied , and *S lativentris* Lw

2 Dissections were made in pure glycerine Glycerine served as an excellent preserving fluid for showing the tracheal system inflated with gas

3 Mature and young larvae of *O cincta* and *O virgo* overwinter in damp moss, decayed bark, and soft wood *Stratiomyia* larvae were found in gravel above the water line of a river during freezing weather Experimentally these larvae survived repeated freezing and thawing

4 The skin is quite impervious to dilute acids, alkalies, alcohol, ether, chloroform, and oils such as kerosene and xylol

5 Each posterior spiracle consists of a heavy chitinous ring within which a lighter ring rests Both rings support chitinous tubes which radiate to a membrane in the central region Gas passes between these tubes rather than through them

6 The anterior spiracles possess "felted chambers," but apparently do not function as passageways for gas Morphologically, it is possible for minute quantities of gas to pass through them, but this was not demonstrated experimentally

7 The larvae used by the writer did not possess lateral spiracles on the metathorax and abdominal somites

8 The respiratory chamber and accessory pouches serve as reservoirs for respiratory gases Muscles extending from the body wall to the chamber open and close the orifice and depress and extend the chamber

9 Young larvae depend on the plumose hairs to maintain themselves at the surface of the water Mature larvae are less dependent upon the hairs for this purpose The hairs are used to inclose bubbles of air either to float the larvae from the bottom to the surface of the water or to supplement the supply of oxygen in the tracheal trunks while the animal is submerged

10 Larvae that are forcibly submerged are able to use dissolved oxygen from the water and to give carbon dioxide to it

11 Analyses of gas liberated from the respiratory system as well as of that obtained by snipping the main tracheal trunks showed a great variation in the percentage of carbon dioxide and oxygen The carbon dioxide content was always high and the oxygen content low as compared with that of air

12 Cutaneous respiration in living larvae has not been proved although experimentally oxygen and carbon dioxide under slight pressure were noted to diffuse slowly through the body wall of dead larvae

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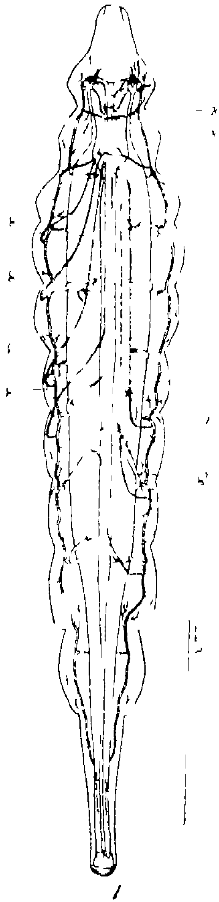
KEY TO ABBREVIATIONS USED IN PLATES

I–X — attachment of spiracular trunks to main trunks
1–10 — dorsal connectives
a — spiracular trunk
abs — last abdominal somite
ac — anterior commissure
ag — accessory ganglionic trachea
agr — anal groove
an — anus
as — anterior spiracle
b — main visceral trachea
bi ms — bifurcated muscle
bl_1, bl_2 — ventral and dorsal blades of orifice
bw — body wall
c — minor visceral trachea
ca — canal in plumose hair
cav — cavity
cm — central membrane
cps — cephalo-prothoracic ganglionic trachea
d_1, d_2, d_3 — tracheae leading to imaginal disks
de — dermis
de c — De Khotinsky cement
d ms — dorsal muscle
e — "ear" of posterior spiracle
ep — epidermis
f — anterior branch of dorsal connective
g — ganglionic trachea
gt — minor connective
h — posterior branch of dorsal connective
hae — haemocoele
ht — main trachea to the head
hy — hypodermis
l — "lip" of posterior spiracle
l ms — lateral muscle
lo ms — longitudinal muscle
lp — large air pouch
lt — lateral trunk
ms — muscle from respiratory chamber to ventral body wall
mt — main trunk
ob ms — oblique muscle
p — pharynx
ph — plumose hair
pl — plumule
ps — posterior spiracle
r_1, r_2 — heavy and light chitinous rings
rc — respiratory chamber
ro — respiratory orifice
s — sternal trachea
sa — stigmatic aperture
sc — stigmatic or "felted" chamber
sh — shaft
sp — small air pouch
sps — spine
t — tergal trachea
tr — tricopora
tr ms — transverse muscle
tu — chitinous tubes in stigmatic chamber of anterior spiracle
tu_1, tu_2, tu_3 — chitinous tubes in the posterior spiracle
v bw — ventral body wall
v ms — ventral muscle

PLATE LXXX



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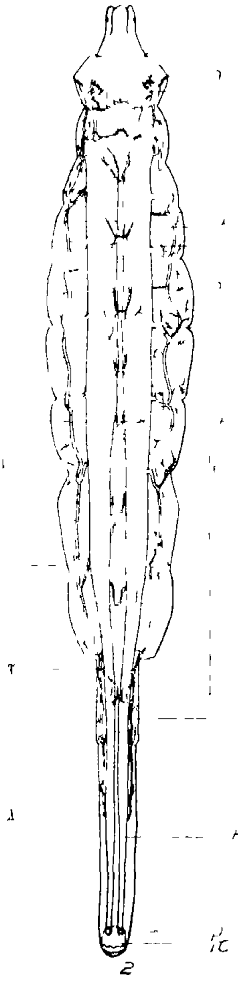

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FIG. 1. Ventral aspect of the respiratory system of *Stratiomyia norma* Wied.
FIG. 2. Dorsal aspect of the respiratory system of *Stratiomyia discalis* Lw.

PLATE LXXXI

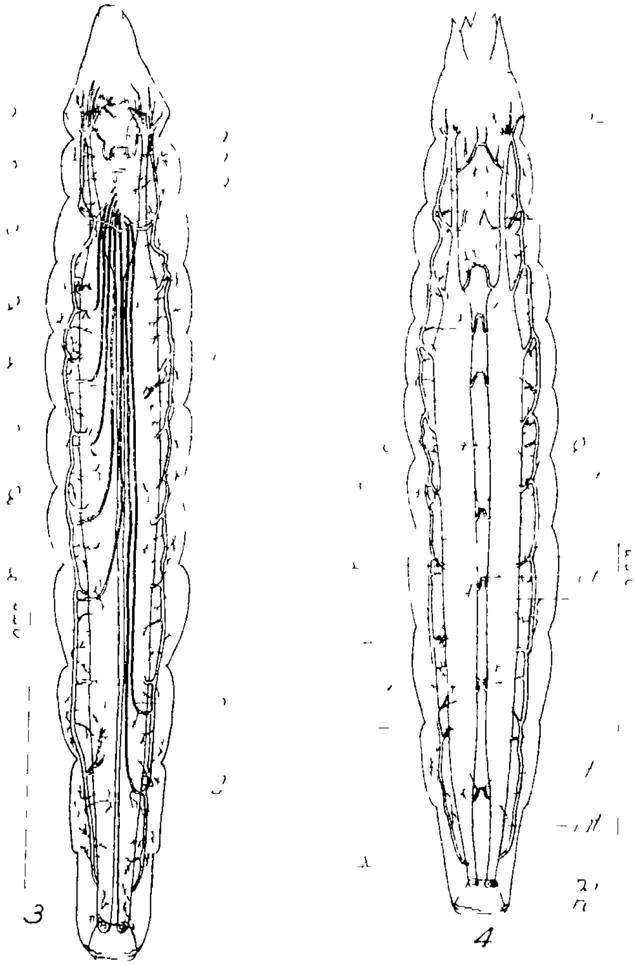


FIG. 1. Ventral aspect of the respiratory system of *Odontomyia cincta* Oliv.
FIG. 2. Dorsal aspect of the respiratory system of *Odontomyia cincta* Oliv.

PLATE LXXXII

Odontomyia cincta Oliv

FIG 5 Diagram of the respiratory chamber posterior spiracles and main trunks

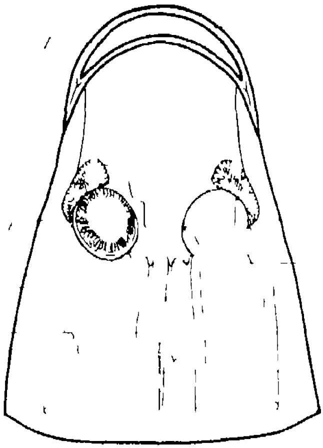
FIG 6 Tracheae of the head and thorax

FIGS 7 9 Sections through the anterior spiracle

FIG 10 Cephalic portion of the posterior spiracle

FIG 11 Caudal portion of the posterior spiracle

PLATE LXXXII



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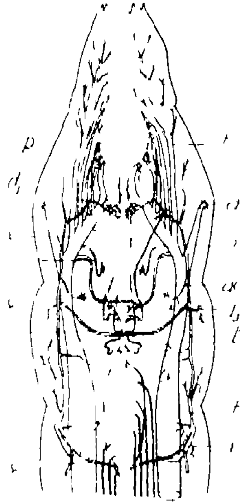

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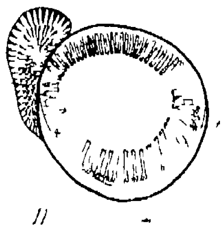

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PLATE LXXXIII

Odontomyia cincta Oliv

FIGS 12–15 Transverse section through the last abdominal somite, showing the muscles and inflated respiratory chamber

FIGS 16–19 Transverse section through the last abdominal somite showing the muscles and deflated respiratory chamber

FIG 20 Transverse section through plumose hair

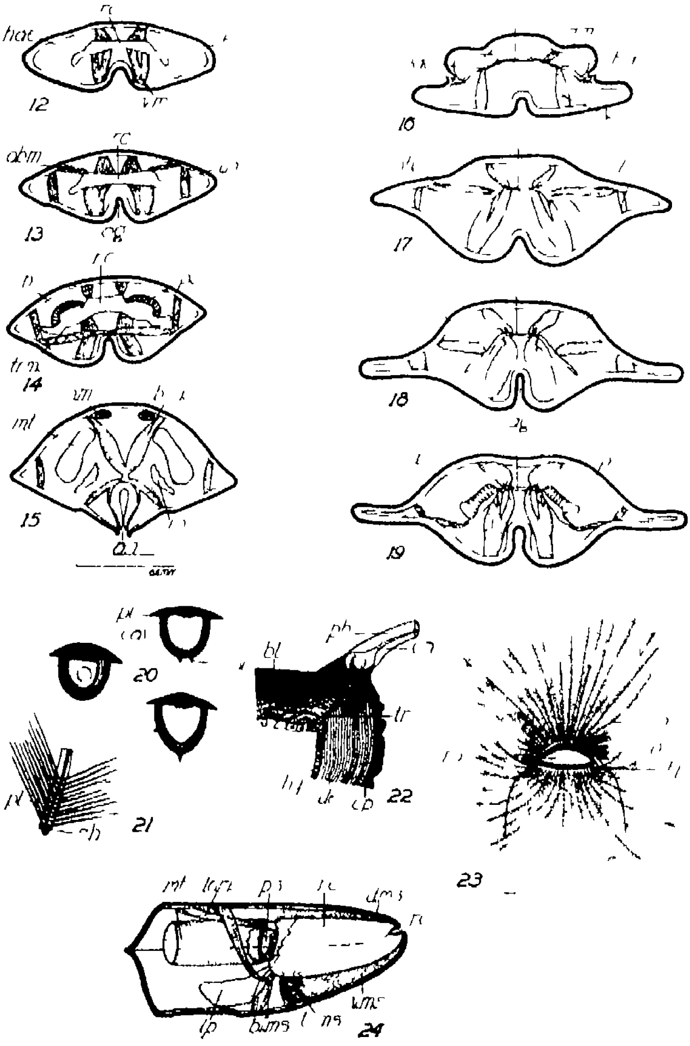
FIG 21 Diagram of a portion of a plumose hair showing the relation of the plumules to the shaft

FIG 22 Section through a plumose hair and chitinous blade of the orifice

FIG 23 End view of the corona of plumose hairs and respiratory orifice

FIG 24 Diagram of sagittal aspect of the last abdominal somite showing the respiratory chamber posterior spiracle main trunk and muscles

PLATE LXXXIII



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